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# **Science & Technology**

***Central Eurasia:  
Engineering & Equipment***

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# Science & Technology

## Central Eurasia: Engineering & Equipment

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31 January 1992

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**Numerical Investigation of Near-Wall Effect on Turbulent Mixing of Jet With Wake in Planar Channels**

927F0063A Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 59-63

[Article by V.N. Gruzdev, I.K. Zhukova]

UDC 532.517.4

[Abstract] The mixing of wakes in channels bounded by walls and the effect of the wall proximity on the wake mixing process in real commercial designs are considered. To this end, a system of equations describing a two-dimensional nonisothermal turbulent flow of an incompressible liquid is derived in a compact notation. Turbulent mixing of a jet with the wake is analyzed using a  $k-\epsilon$  turbulence model for a series of jet and wake ratios. The results indicate that starting with a certain value of the jet constriction factor (the ratio of the wake area to the sum of the wake and jet areas), the flow pattern considerably depends on that factor as a result of a noticeable change in the longitudinal pressure gradient. The calculation is made on a computer using the nonuniform difference net method. The results show that the flow pattern during the wake mixing with the jet in the channel is determined by the interaction of the velocity fields and static pressure. A comparison of experimental and analytical data demonstrates their adequate quantitative and qualitative consistency. Figures 4; tables 2; references 4: 3 Russian; 1 Western.

**Models of Gas Dynamic Loads on Oscillating Nozzle Shell**

927F0063B Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 63-67

[Article by A.A. Sergiyenko]

UDC 533.6.013.422

[Abstract] It is shown that the principal method of improving the jet engine performance is to increase its thermal efficiency (KPD) by increasing the degree of working medium expansion, i.e., the ratio of the pressure in the chamber to that in the nozzle outlet section. Models of the gas dynamic loads developing during an infinite uniform planar flow over an wavy oscillating slab with a three-dimensional periodic small displacement structure are investigated. The areas of super- and subcritical flow over traveling and standing displacement waves are determined and critical flow conditions as a function of the mean flow velocity, oscillation frequency, and wavelength ratio of the periodic structure with a staggered crest arrangement are identified. Conditions of flow over traveling and standing displacement waves both with a wave drag and thrust are determined. The resulting models of gas dynamic loads on the vibrating shell in the gas flow differ significantly from those based on steady-state Prandtl-Mayer and A.A. Ilyushin flows. References 3.

**Tuning out of Natural Blade Resonance in Axial Compressor Blade Rim CADs**

927F0063C Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 67-71

[Article by V.V. Bibikov]

UDC 621.408-519.68

[Abstract] The method of tuning out of natural frequency resonance of turbine blades on the basis of their efficiency factor is considered and the algorithm for incorporating the frequency tuning out parameters into the computer-aided design system (SAPR) of axial compressor blade rims (LV) is examined. The algorithm is realized as a program written in the Fortran-IV language with the help of software developed by V.N. Tyulenev. The procedure is illustrated by the example of tuning out the natural resonance frequency of a cantilever-mounted guide vane blade made from steel Ye1961Sh. Many similar experiments confirm the reliability of this tuning-out algorithm and show that depending on the number of modes being tuned out and the constraints imposed on the manipulated variables, processor time outlays of a unified series YeS-1061 computer are close to 5-20 min. Figures 2; tables 1; references 3.

**Method of Determining Optimal Makeup of Parameters Measured in Gas Turbine Engine Diagnostic Check**

927F0063D Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 71-75

[Article by G.E. Grechikha]

UDC 629.7.083.036.1.004.58

[Abstract] It is shown that the diagnostic accuracy of complex entities, such as gas turbine engines (GTD), largely depends on the makeup and number of parameters being measured, so in order to synthesize a gas turbine diagnostic check system, it is necessary to determine the optimum makeup of diagnostic variables which ensure the maximum confidence of the procedure. The problem is formulated and an algorithm for estimating the diagnostic variable value of gas turbine engines and other entities is proposed. The algorithm makes it possible to determine on-line the optimum makeup of the parameters measured for given diagnostic check conditions. The variables' diagnostic value is defined as the difference between the quantity of legitimate information (or legitimate signals) and "noise" contributed by the parameters being measured, i.e., the measurement errors. The procedure is illustrated using the example of determining the optimum diagnose variable makeup of a three-shaft bypass turbojet engine (TRDD). In the case where the number of unknowns in the gas turbine engine model is greater than the number of parameters with a positive diagnostic value, the problem may be solved only with a certain probability in the framework of a certain parameter deviation hypothesis. Tables 2; references 8.

**Investigation of Heat and Mass Transfer in Porous Heat Exchangers**

927F0063E Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 75-79

[Article by S.A. Danilov, V.N. Fomin]

UDC 532.546

[Abstract] The importance of investigating the heat and mass transfer phenomena under forced heat transfer agent flow conditions in porous heat exchangers for designing compact heat exchangers for the aerospace industry and the use of computational methods for this purpose is emphasized. The results of numerical analyses of the heat and mass transfer process in compact porous heat exchangers allowing for the geometrical and design properties of the permeable layer and header system, the inhomogeneity and anisotropy of the porous system, and the nonuniformity of heat transfer agent rate distribution inside the porous layer which depends its inlet and outlet condition are presented. Recommendations are given for selecting optimal geometrical, thermal, and hydrodynamic design parameters of such heat exchangers. Heat exchange in the device is simulated by a system of differential equations which characterize the heat and mass transfer in permeable porous media. It is noted that design parameters of porous heat exchangers should be selected in the domain of the least manifested optimum which ensures reliable operation of the prospective devices. Figures 4; references 9.

**Effect of Fuel-Air Mixture Inhomogeneity on Benzopyrene Production Rate During Hydrocarbon Fuel Combustion**

927F0063F Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 79-81

[Article by S.V. Lukachev, S.G. Matveyev, M.Yu. Anisimov]

UDC 621.452.32.086:543.272.75.05

[Abstract] Benzopyrene (BP) - the strongest and most stable carcinogen among polycyclic aromatic hydrocarbons which are present in the exhaust of aircraft gas turbine engines (GTD) along with other toxic substances, such as nitrous oxides, carbon monoxide, and unburned hydrocarbons and is used as an indicator - and the factors determining its production rate in the combustion process of hydrocarbon fuels are examined. A study of benzopyrene synthesis during the combustion of homogeneous propane-and-air mixtures carried out at the Kuybyshev Aviation Institute reveals that the initial composition of the fuel-air mixture (TVS) plays a dominant role in this process; the study also identified the threshold excess-air coefficient (0.6 at 240K and 0.098 MPa) above which no benzopyrene traces are found in the combustion products. The investigation makes it possible to speculate that the benzopyrene production rate in combustion chambers (KS) is determined by the physical processes of fuel

atomization and its mixing with the air to a greater extent than by the chemical reaction kinetics. Figures 2; references 5.

**On Analyzing Equilibrium Compositions by Step-by-Step Method**

927F0063G Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 82-84

[Article by R.R. Nazyrova, A.A. Dregalin]

UDC 536

[Abstract] The need to carry out multiversion thermodynamic analyses of the working medium parameters and combustion product properties in simulating the processes occurring at high temperatures and designing engines and the increasingly stringent requirements being imposed on such analyses and designs are discussed and it is suggested that thermodynamic analysis and computation methods and algorithms be modified substantially for developing efficient software and meeting these requirements. The results of a numerical analysis of the method of analyzing the equilibrium composition of multicomponent mixtures consisting of molecular and atomic substances, both condensing and gaseous, are presented and the expediency of using the step-by-step method developed for this purpose in order to replace the iterative procedure which is inefficient in this case is demonstrated. The step-by-step method algorithm is described. The development of the new method which takes into account the discreteness of the system of equations simulating the fuel mixture makes it possible to solve the equilibrium composition analysis problem without using other methods. Figures 3; references 3.

**Forming and Welding of Sandwich Bottoms in Superplastic State**

927F0063H Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 84-88

[Article by A.V. Orekhov, A.G. Pashkevich, V.I. Mikheyev, Yu.I. Kaznacheyev, A.Ye. Volkhonskiy]

UDC 621.983

[Abstract] The process of making three-layered sandwich aircraft bottoms by taking a flat stack of skins and a filler with an antiwelding coat applied to it with subsequent diffusion welding of the stack, thermal pressure molding (PTF) of the stack to a given height, and expansion of the stack by compressed gas to a given bottom thickness is summarized. It is shown that the best way of making a sandwich bottom is to use a corrugated filler of an equal or varying width in the meridional direction. The molding-welding of sandwich bottoms in the superplastic state is considered and analytical expressions are derived for determining the loading process parameters. The relationships between the initial skin and filler thickness for a given filler configuration and the number and height of corrugations which makes it possible to produce sandwich

bottoms without buckling and shrinkage defects are established. The loading curves are plotted assuming that the forces on the normal to the bottom surface in an equilibrium. Figures 3; references 3.

**On Effect of Wake on Sound-Proofing of Aircraft Structures**

927F0063I Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 89-91

[Article by A.V. Generalov]

UDC 534.833.53

[Abstract] The use of multilayered sandwich structures for enhancing the sound-proofing of aircraft and methods of designing sound-proofing sandwich structures by the transition probability matrix and impedance procedures are discussed. A general problem of sound wave reflection from, and transmission through, sandwich structures contiguous with the moving medium is analyzed and the specific cases of the dependence of the polystyrene layer sound-proofing at a 100 Hz frequency on the wake angle of incidence at various Mach numbers and the dependence of the this layer's sound-proofing on frequency at various angles of incidence are examined. The layer's sound proofing is defined as its transmission loss or the ratio of the transmitted sound intensity of the wave incident upon the layer to the sound intensity of the reflected wave. An analysis of the results makes it possible to conclude that the wake increases the sound-proofing of aircraft structures and that the greatest positive effect is achieved by positioning the engine in the aircraft's tail section. Figures 3; references 7: 6 Russian; 1 Western.

**Investigation of Nonlinear Taut Strain State of Spring-Type Gear**

927F0063J Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 91-93

[Article by V.V. Kuznetsov, Yu.V. Soynikov]

UDC 539.3

[Abstract] Studies of nonlinear straining of spring gears by means of variable cross section rod straining models as well as curved and twisted rods are summarized and approximation relationships of the theory of shells developed by the authors are used to describe the nonlinear straining of spring gear. A gear spring representing a shell with an unfolding median surface which can be determined with the help of Cartesian coordinates and direction cosines of an orthogonal trihedron are considered. Strain and curvature tensor components in the case of large displacements are described by local approximation relationships. Lagrange's method is used to solve the problem of determining the equilibrium forms, the equilibrium states which meet the above form-function condition in the sub- and supercritical strain regions are found by iterations, and stability of equilibrium states is investigated by the positive definability criterion of the second total potential energy variation. A gear spring consisting of

24 shell elements is considered for illustration; the mechanical characteristics of the spring made from a titanium alloy are presented. The maximum stress realized in the spring near various supports is determined. Figures 3; references 7: 4 Russian, 3 Western.

**Investigation of Two-Dimensional Spline Boundary Condition Version in Surface and Outline Simulation**

927F0063K Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 93-96

[Article by A.N. Rotkin, V.F. Snigirev, V.G. Shatayev]

UDC 514.539.3

[Abstract] The shortcomings of difference method of solving application problems involving interpolation or approximation of surfaces and outlines by splines whereby the spline's boundary conditions are unknown are identified and two version of quadratic spline functionals are considered; of these, the version containing the boundary conditions for the spline nodes is examined in greater detail. A system of linear algebraic equations is derived from the quadratic form minimum condition obtained from the spline functional with the help of approximating functions for the spline's finite elements (KE). The spline reaction and its two components each of which can be independently determined are analyzed. The results of a numerical experiment to interpolate a surface by a spline with the help of tetragonal finite elements are cited. The numerical results demonstrate that both spline functional versions ensure a virtually identical convergence while the version not considered is somewhat more accurate. The functional makes it possible to determine the boundary value conditions for interpolating a surface by a two-dimensional spline and its accuracy is sufficient for practical applications. Figures 1; references 5.

**Penetration Depth of Liquid Jet Saturated With Gas Bubbles**

927F0063L Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 96-98

[Article by V.N. Avrashkov, S.I. Baranovskiy, D.M. Davidenko]

UDC 582.529.5

[Abstract] Liquid jets delivered to the supersonic gas flow at a certain angle to control the nozzle thrust vector of mixing units in a straight-flow combustion chamber and the jet penetration depth - one of the most important determining the efficiency of such devices - are considered. The possibility of controlling the liquid jet penetration depth by saturating it with bubbles (or sparging) is investigated. At a fixed flow rate, bubble injection into the liquid reduces the mixture density and proportionately increases the jet outflow velocity as a result of which the velocity head of the two-phase gas and liquid jet rises and thus increases the penetration depth. Experiments in which a TS-1 kerosene jet or a mixture of kerosene and air



bubble was injected into a supersonic effluent air flow confirm the efficacy of saturating the liquid with gas bubbles. A constant kerosene rate was maintained while manipulating the gas concentration in the mixture. The analysis of the gas bubble-saturated jet penetration depth was made assuming that the outflow laws of the gas-liquid mixture and the liquid are identical, i.e., the gas-liquid mixture is equivalent to a liquid of lower density. An expression is proposed for estimating the parameters of the system of jet injection of a gas bubble and liquid mixture; the results obtained with its help are quite consistent with the results of experimental studies. Figures 3; references 3: 2 Russian, 1 Western.

#### **Effect of Eulerian Inertial Forces on Stressed State of Rotating Aircraft Turbine Plant Parts**

927F0063M Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATSIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 99-102

[Article by A.Yu. Dronnik]

UDC 621.431.75

[Abstract] The effects of Eulerian inertial forces during the aircraft (LA) flight on the rotating parts of its turbine plant is investigated and the stresses developing in the parts as a result of these forces are evaluated in light of the fact that according to statistical data, more than 80% of all possible aircraft engine failure causes are due to the failures of rotating turbine plant parts. The possibility of increasing the operating reliability of the turbine plant by fully taking into account the effect of forces on the stressed state of the aircraft turbine's rotating parts is examined. The forces affecting the stressed state of the turbine's and compressor's rotating parts consist of constant and alternating with respect to both their magnitude and direction; inertial forces are divided into translational, i.e., normal and tangential on the one hand, and Coriolis forces on the other. It is noted that Eulerian inertial forces are usually ignored in strength analyses, so the effect of Eulerian inertial forces on the stressed state of rotating aircraft turbine plant parts is illustrated by considering an aircraft turbine blade during the turbine rotor acceleration. In so doing, the rotational speed is assumed to be equal to  $160 \text{ s}^{-1}$  at a certain moment when the aircraft is moving with acceleration along an arc of a circle with a radius of 500 m while at the same time revolving around its longitudinal axis. The results show that the stress resulting from Eulerian inertial forces varies from several percentage points to tens of percentage points of the permissible limit; the resulting stress is superimposed on the almost ultimate tensile and bending stress developed by centrifugal and gas pressure forces; the stressed state in rotating turbine parts developed by Eulerian inertial forces may be at times characterized as the stressed state from an impact load and, consequently, the stress analysis must be adjusted correspondingly; and transient conditions appearing during the aircraft evolutions are especially dangerous. Thus, Eulerian inertial forces must be taken into account in the strength analyses of rotating aircraft turbine plant parts. Figures 2; references 4.

#### **Selection of Optimal Antigravitational Heat Pipe Characteristics**

927F0063N Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATSIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 102-104

[Article by N.I. Klyuyev, V.D. Semashko, S.B. Shcheglov]

UDC 586.248

[Abstract] The problem of optimizing an aircraft design, whose principal parameter (in addition to some functional characteristics) is its mass, by matching and selecting the most favorable geometrical and technical design specifications is considered. To this end, the hydrodynamic characteristics of an antigravitational heat pipe in a steady-state operating conditions with a thermal power balance are established. The design of an antigravitational heat pipe consisting of an evaporator, a principal condenser, an auxiliary condenser, a pipeline, a condensate line, a liquid lock, and a capillary porous insert is presented. The problem of optimizing the geometrical parameters of the antigravitational heat pipe is reduced to a system of partial differential equations; its solution makes it possible to determine the antigravitational heat pipe parameters for minimal pressure losses. An analysis of the proposed procedure demonstrates that it makes it possible to optimize the inside diameters of steam and condensate lines and specify optimal operating conditions of the antigravitational heat pipe. Figures 3; tables 1; references 3.

#### **Test Bench for Investigating Power Plant Static Charge Accumulation**

927F0063O Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATSIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 105-107

[Article by G.P. Potapov, G.B. Muravyev, R.Kh. Sabirov, T.A. Chakkayev, A.A. Zadnev]

UDC 629.7.036.3.008.6:621.3.01

[Abstract] The static charge accumulation by a power plant due to its loss of unipolar charged particles with the exhaust gas jet is discussed and the relationship between the electric parameters (EFP) characterizing the static charge accumulation by power plants (electrization) and the parameters of the thermal and gas dynamic processes occurring in them is examined from the viewpoint of engineering diagnostics, preventing the negative effect of the resulting RF interference, protecting the environment, as well as fire safety and other issues. A test bench for investigating the electrization of power plants consisting of a burner, a fuel (propane-butane mix) delivery system, an air delivery system, and instruments for recording the operating conditions and electric parameters is described. The effect of various aerosol particles in the combustion products, i.e., soot, dust, and metallic particles, and the chemical composition of the fuel on the physical parameters of power plants is examined. Test bench performance in various operating conditions shows that the measurement technique is quite reliable and the data are reproducible, making it possible to regard the unit is suitable for

examining the dependence of electrical parameters on the operating conditions of power plants. Figures 1; references 3: 2 Russian; 1 Western.

**Effect Axial-Flow Microturbine Nozzle Diaphragm Blade Height on Velocity Factor and Efflux Angle**

927F0063P Kazan IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 4, Oct-Dec 90 pp 107-109

[Article by N.T. Tikhonov, E.E. Pfyfle]

UDC 621.438.001.2(03)

[Abstract] The importance of establishing the effect of the axial-flow microturbine (MT) nozzle diaphragm blade height on the velocity factor and efflux angle for increasing the confidence of microturbine analysis and designing high-efficiency (KPD) microturbine is emphasized. Since the effect of the microturbine (MT) nozzle diaphragm blade height on the velocity factor and efflux angle cannot be investigated analytically, the study was carried out in an experimental unit by static wind tunnel testing making it possible to measure the efflux angle and velocity factor. To this end, six nozzle diaphragms with different blade heights were manufactured; the blade cascades had a constant mean diameter and the same leading and trailing edge thickness, duct entrance diameter, optimal chord spacing ratio, number of channels, and partiality degree. The data obtained in the tests are valuable for reliably analyzing the axial-flow microturbine stages and designing the impeller blade profile. Despite its limitations, the experiment makes it possible to state that the development of microturbines with a relative blade height of less than 0.04 mm is fraught with a noticeable decrease in their energy efficiency. Figures 2; references 4.

**'User-Finite Elements Method Model' Interface Based on DBMS Concept**

927F0063Q Kazan IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 4, Oct-Dec 90 pp 109-111

[Article by V.A. Zarubin]

UDC 381.3:629.7

[Abstract] A conceptual schema developed for storing and handling data in the computer-aided design system (SAPR) for structural designs of aircraft (RIPAK) is considered. Availability of a database with such a system to any design office would enable the designers to process data obtained from finite elements method (MKE) models on-line and make sound design decisions. A new design technology based on using the results of analyses and optimization obtained with the help of finite elements method models at all design stages made possible by the development of powerful commercial CADs and FEM

systems is described. The new systems have a network architecture, so the user-model interface in them are possible only on the basis of the database (BD) concept. A specific conceptual schema enables the designer to obtain answers to unscheduled questions regarding the strength, rigidity, dynamic, aeroelastic, and other characteristics of the design in progress by accessing the database in the data manipulation language (YaMD), bypassing the computer engineer in his role of a middleman between the designer and FEM model. Block diagrams of the database conceptual schema and SAPR RIPAK architecture are presented. The proposed CAD system is adaptable: it maintains its high efficiency of the routines stored in the user data archives (ADP), ensures an easy transition to another DBMS (SUBD), and makes it possible to develop supervisory programs. Availability of such a database to a design office also ensures on-line data processing efficiency, standard data storage methods, and the possibility of processing data in computer (EVM) networks. Figures 2; references 5.

**Automated Equipment Configuration in Maneuverable Aircraft Fuselage**

927F0063R Kazan IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 4, Oct-Dec 90 pp 111-113

[Article by O.B. Pashchenko]

UDC 629.7.01:681.3

[Abstract] The issue of efficient arrangement of equipment systems in the inner configuration of the maneuverable aircraft fuselage during the conceptual design stage is addressed and the sequence of procedures involved in solving the efficient equipment configuration (RKO) design task is outlined in detail. The equipment configuration and load-factor layout (KSSR) is shown with the position of mounting elements, i.e., various types of frames, arms, shelves, and floors for each compartment. It is shown that optimal cable layout decreases the length of airborne electronic equipment (BREQ) cables and their mass. The efficient equipment configuration task is mathematically formulated as an optimization problem; a heuristic method of synthesizing the equipment configuration in a maneuverable aircraft (MS) fuselage on the basis of formalized techniques used by the designer in practical applications is described; the resulting design process model is developed in the form of a generalized algorithm. Pilot operation of the configuration design system demonstrates that the proposed method makes it possible to develop efficient compartment configurations with a space utilization factor of 0.5 or higher, control the design interrelation between the equipment configuration and fuselage flight performance, and solve the problem of synthesizing the equipment configuration in the maneuverable aircraft fuselage while serving as a tool for analyzing configuration designs. Figures 2; references 4.

**Center-of-Gravity Range of Various Configurations of Light Airplanes**

927F0062A Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 3-7

[Article by A.A. Badyagin, (deceased)]

UDC 629.735.33.001.2

[Abstract] The factors taken into account in evaluating and selecting an aircraft's aerodynamic configuration - the lift/drag ratio and its losses to balancing, structural mass, and center-of-gravity range - are discussed and the latter factor is investigated in greater detail for five configurations: classical, canard wing, tailless, triplane, and tandem. The assumptions used in the study are outlined. An analysis of the results demonstrates that the center-of-gravity range depends primarily on the horizontal tail surface area and length as well as the horizontal tail surface configuration relative to the wing along the airplane length; the tandem arrangement ensures the longest center-of-gravity range while the canard wing - the shortest; and finally, the center-of-gravity range does not depend on the relative coordinate of the wing center of pressure. Figures 3; tables 1; references 3.

**Limit of Mass Outlay Ensuring Expediency of Modifying Passenger Airplane**

927F0062B Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 8-11

[Article by V.P. Gogolin]

UDC 629.735.33.01

[Abstract] The problem of determining the maximum permissible additional mass outlays for designing a base passenger airplane for operation over routes of varying length with the maximum commercial payload is considered; it is stated that the base airplane may be modified at the expense of increasing its mass ensuring its operation with an increased or decreased fuselage length. These mass outlays are found from the condition that the algebraic sum of the effects attained from operating the base airplane and its modifications over routes of varying length be equal to zero. The problem is solved with respect to the initial design phase when the base airplane development is considered as a range of alternatives. The concept of the mass increment factor which makes it possible to determine the total change in the airplane mass when partial mass components are changed underlies the mass outlay feasibility. A hypothetical airplane corresponding to Tu-154 is considered for illustration. A preliminary estimate shows that real mass outlays for such a plane amount to about 2,000 kg, making it possible to draw the conclusion that the effect from developing a base airplane with a built-in modification capacity is feasible if the ratio of the number of modification for the shortest and longest routes to the number of base airplanes and their modifications is 0.25-1.00. Tables 1; references 3.

**'Triplane' Center-of-Gravity and Horizontal Fin Assembly Parameter Optimization Allowing for Stability and Handling Augmentation System Capabilities**

927F0062C Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 11-14

[Article by V.P. Surin, O.P. Zorina, Yu.I. Maltsev]

UDC 629.735.33(07)

[Abstract] The outlook for using airplane stability and controllability augmentation systems (SUU) which make it possible to ensure the requisite airplane flight performance (LTKh) by selecting its aerodynamic configuration parameters is discussed; the problem selecting the aerodynamic configuration parameters of a "triplane" aircraft equipped with an automatic pitch control system by the integral energy maneuverability criterion is considered; the triplane configuration has a horizontal canard wing (PGO) positioned close to the wing. In solving the problem, the automatic pitch control system is treated as a static automaton. In so doing, the parameter optimization task is formulated as a nonlinear programming problem. The effect of the load factor on the energy maneuverability indicators is considered; it is shown that at load factors of  $<3$ , the energy maneuverability indicators increase primarily due to a decrease in the static stability margin and an increase in the total lifting surface area while at  $>3$ , there is an additional effect of vortical PGO interaction with the wing. Figures 3; references 5: 4 Russian, 1 Western.

**Tear-off Interlayer Stresses in Composite Fibrous Material Balloons**

927F0062D Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 14-17

[Article by Ya.G. Antsilevich, B.G. Mayorov, S.B. Chervatskiy]

UDC 629.074:539.3

[Abstract] The strain in a positive pressure balloon made from a composite material with a symmetric filament arrangement relative to the meridian and stiffened by circular braiding over its cylindrical section is considered. The balloon consists of three layers - a base layer, a fitting layer, and a circular layer. It is assumed that the structure represents a monotropic axisymmetric net, circular filaments, and an isotropic binder layer working together. The principal equilibrium equations are derived and the binder deformability and adhesive strength are taken into account. It is shown that tensile interlayer stresses develop in the balloon's cylindrical section where it tapers off toward the bottom due to negative circumferential deformations; as a result of these stresses, the braiding is torn off from the base layer. The problem of finding these tear-off stresses is solved on a computer (EVM) by the zeroing-in method. Three zones are identified in the binder layer behavior: binder tear-off from the base layer filaments

near the equator and near the polar opening and elastic deformation in the intermediate section. Figures 2; references 2.

**Fatigue Resistance Prediction and Strength Parameter Estimation of Microscopic Volumes of Material**

927F0062E Kazan IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: AVIATIONNAYA TEKNIKA in Russian No 4, Oct-Dec 90 pp 18-21

[Article by V.M. Duplyakin, T.D. Kovalenko, R.E. Minoranskiy]

UDC 539.385

[Abstract] Prediction of the statistical characteristics of endurance strength on the basis of endurance failure similitude equations suggested by V.P. Kogayev whereby failure is understood as the development of macrocracks and its constraints are discussed and a more general approach in the framework of the "weak" link theory which is free of the aforementioned limitations but requires cumbersome computations is considered. The obstacle to developing and extending the above approach due to the difficulty of estimating the parameters of materials from the results of laboratory tests of samples is analyzed and a procedure for overcoming the problem is proposed. To this end, the results of lab tests of samples are presented as a family of quantile fatigue curves which are generally described by normal distribution of the normal life logarithm. Algorithms and a computer program are compiled on the basis of the procedure, making it possible to find estimates of the material's parameters from the results of lab tests of various types of samples; the efficiency of this program is illustrated by processing experimental data obtained by bending tests of round smooth samples of 30KhGSA. The results attest to the high efficiency of the proposed technique and software. Figures 2; tables 3; references 3.

**Effect of Delamination on Load-Carrying Ability of Sandwich Plates**

927F0062F Kazan IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: AVIATIONNAYA TEKNIKA in Russian No 4, Oct-Dec 90 pp 21-24

[Article by Yu.V. Skvortsov, Kh.S. Khazanov]

UDC 629.7.015.4:539.3

[Abstract] Three-layered structures with a light filler which are most vulnerable to delamination either during their manufacturing or operation are discussed and it is shown that two problems arise in studying the effect of delamination on the load-carrying ability of such laminated plates: analyzing their taut strained state (NDS) and determining the maximum dimensions of safe, i.e., nonspreading, defects. The finite elements methods (MKE) is used to analyze the taut strained state whereby the composite finite element is composed of parts of the shell and the filler according to the open polygon hypothesis; it is assumed that the filler works only in transverse shear while the shell strain is subject to Timoshenko's hypothesis. A

simple delamination simulation method is considered whereby shear rigidity in the filler defect zone is assumed to be equal to zero; it is suitable if there is no buckling. The method is used to solve the problem of the effect of square delamination on the taut strained state of a square three-layered plate loaded by a uniform pressure. The increase in the delamination zone is attributed to the intensity of energy release in the defect zone. To be able to determine strain near the defect front, a modified crack closure method is used. The problem of determining the energy release rate along the square delamination perimeter is solved using the above modified method; the results demonstrate that the defect zone grows at first in the middle of the sides, so the square delamination is gradually transformed into a round one. Figures 5; references 5: 4 Russian; 1 Western.

**Engine Process Lag Calculation in Problem of VTOL Aircraft Control Synthesis**

927F0062G Kazan IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: AVIATIONNAYA TEKNIKA in Russian No 4, Oct-Dec 90 pp 24-28

[Article by A.I. Bogomolov, P.K. Semenov]

UDC 683.513.5

[Abstract] The issue of parametric synthesis of decoupling filters (RF) for the manual control system of vertical takeoff and landing aircraft (SVVP) which makes it possible separately to control the velocity ratios in takeoff and landing flight regimes is discussed. The synthesis problem is solved on the assumption that processes in the controller are not instantaneous, so the engine process dynamics are taken into account. The problem of compensating the effect of the engine process lag in the VTOL aircraft is thus solved. A block diagram of the VTOL aircraft controller with the decoupling filter is presented and a mathematical model of the longitudinal perturbed VTOL motion is derived. The engine process lag is taken into account as a first-order aperiodic matrix element. To confirm the feasibility of practical application of the concept of compensating the effect of the engine lag on the quality of velocity ratio decoupling, control processes are numerically simulated; in so doing, the parametric and structural deviations of the VTOL aircraft engine dynamics from the model are taken into account. An analysis of structural perturbations shows that a good motion decoupling is maintained. Ye.N. Nikonov helped with the calculations. Figures 3; tables 1; references 2: 1 Russian, 1 Western.

**Aircraft Landing Control in Zero-Overshoot Response Mode**

927F0062H Kazan IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: AVIATIONNAYA TEKNIKA in Russian No 4, Oct-Dec 90 pp 28-33

[Article by A.I. Zoteyev]

UDC 629.735.05

[Abstract] The problem of controlling a flight vehicle (LA) in the vertical plane during landing is discussed; the problem is reduced to determining the control actions

which ensure the aircraft center-of-mass motion along a given path. A nonlinear aircraft control law during the landing flight phase is proposed. The control law is developed on the basis of the force control principle in the class of piecewise-linear functions with first-kind discontinuities and employs aircraft motion along a given path in the zero-overshoot response mode. The speed of the aircraft in the landing path which is treated as a controlled entity consists of the ground speed and speed of descent; the former is controlled by manipulating the thrust while the vertical component of the speed of descent is controlled by manipulating the lift with the help of an additional error signal in the control law. References 7.

#### **On Problem of Optimal Correction of Airborne Complex Flight Test Program**

927F0062I Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 33-38

[Article by V.A. Talyzin]

UDC 629.7.018.7

[Abstract] The problem of test flight correction is extended to the case where a certain number of additional airborne complex (AK) checks have to be distributed among several flights whereby they may be incorporated into the flight test program repeatedly in order to increase the check accuracy. In so doing, the airborne complex flight test program correction involving only two test flights is considered for simplicity's sake. In solving the problem of optimal incorporation of additional airborne complex tests into the existing flight experiment program, the cost and probability of successful flight test completion are taken into account in the optimality criterion. It is assumed that failure to execute any one check carries a penalty whose magnitude does not depend on the number of additional checks which have not been executed. After the problem is formalized, it is reduced to a problem of discrete programming with constraints. It is suggested that the resulting problem be solved by the method of successive optimizations. Armed with optimal airborne complex flight test program correction versions for various values of the penalty function, the test director makes the final decision by choosing between the cost and probability of successful completion of additional flight tests. Tables 2; references 2.

#### **Stabilization of Dynamic Entities With Unknown Transient Parameters Using Linear and Adaptive Control Movements**

927F0062J Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 38-40

[Article by B.V. Ulanov]

UDC 62-50

[Abstract] Methods of stabilizing modern flight vehicles (LA) which are characterized by a wide range of parametric perturbations are discussed; it is shown that these methods are subject to parametric perturbations which vary randomly within a broad range. The possibility of solving this

problem in the class of linear and adaptive control functions is investigated. The design of linear stabilizing aircraft control is synthesized and it is demonstrated that adaptive control movements may also stabilize an entity with parametric perturbations varying randomly within any unknown but limited range, i.e., the entity may be stabilized without assuming that parametric perturbations change according to a quasistationary law. References 3.

#### **Effect of Inertial Forces on Long Hydrodynamic Vibration Damper Characteristics With Transient Flow Conditions**

927F0062K Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 40-43

[Article by V.B. Balyakin, A.I. Belousov]

UDC 621.438

[Abstract] Long hydrodynamic dampers (GDD) are used in rotor bearing for decreasing the vibration in modern aircraft gas turbine engines (GTD); the trend toward higher rotor speeds leads to cavitation in the damper's lubricant layer and an increase in inertial forces. Moreover, the laminar lubricant flow becomes turbulent in some regions as a result of which we are dealing with a transient flow condition. The lubricant flow in the damper clearance of the long hydrodynamic damper in the transient (or mixed) condition with a circular synchronous precession is described by the modified Reynolds equation while axial flows are ignored for simplicity's sake. The effect of convective inertial forces on the dynamic characteristics of the damper under such mixed conditions is evaluated and it is shown that inertial forces lead to the development of a negative radial hydrodynamic force component which, in turn, facilitates an increase in the rotor vibration amplitude. Convective inertial forces are taken into account using N.A. Slezkin's and S.M. Targa's method. It is shown that in aircraft gas turbine engines with a rotor bearing radius of  $\geq 70$ -100 mm, the damper clearance in the long hydrodynamic vibration damper must be at least 0.2-0.3 mm; in order to eliminate cavitation at high values of the parameter  $\sigma$ , the relative eccentricity must be less than 0.15. If this is impossible, the lubricant delivery pressure should be increased. Figures 4; references 3.

#### **Analysis of Transonic Flow Over Planar Compressor Cascades by Method of Large-Size Particles**

927F0062L Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 44-47

[Article by L.G. Boyko, V.N. Yershov, A.Ye. Demin, D.V. Kalyamin]

UDC 621.44.533.697

[Abstract] The difficulty of mathematical modeling of transonic flows over compressor cascades due to the three-dimensional transient character of the flow, the presence

of shock waves, their interaction with the boundary layer, separation, and other phenomena is discussed. The method of large particles developed by O.M. Belotserkovskiy and Yu.M. Davydov whereby the initial nonstationary system of motion equations of a nonviscous compressible gas without heat conduction is separated into individual physical processes is considered. To this end, the medium is simulated by a system of liquid particles which at a given time moment coincides with the cells of Euler's net. At each time step the analysis is performed in three stages. A steady state solution is derived by settling the process in time. The method makes it possible to analyze sub-, trans-, and supersonic regimes of flows over a planar profile cascade. The problem is mathematically formulated and the results are presented for the case of subsonic flow velocities on the inlet. The calculation is made on a unified system YeS 1061 computer (EVM). The outcome makes it possible to conclude that the computational algorithm and programs developed on the basis of the finite difference particulate method are suitable for analyzing the flow over compressor cascades. Figures 4; references 8.

**Investigation of Stationary Flow Over Spatial Carrying Systems at Subsonic and Supersonic Flow Conditions by Discrete Vortex Method**  
927F0062M Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 48-50

[Article by A.M. Valuyskiy, S.S. Graskin, V.A. Podobedov]

UDC 533.6.011.5

[Abstract] The development of computer-aided design systems and the emergence of consolidated mathematical models (MM) of aircraft prompted the development of unified approaches to investigating the processes of sub- and supersonic flow over various entities. For planar monoplane wings, such approaches are developed on the basis of the discrete vortex method (MDV). The results of the development of a unified mathematical model for examining sub- and supersonic flows over spatial carrying systems of the lattice wing (RK) type are presented. The problem is solved in a linear formulation on the basis of the assumptions adopted in the linear theory. The spatial carrying system and the vortical wake behind it are simulated by a family of transverse and longitudinal bound and free vortex sections. In this case the problem is reduced to a system of  $N$  linear algebraic equations which represent the condition of the entity's surface impermeability at  $N$  check points. The results attest to the fact that the proposed procedure makes it possible to use the discrete vortex method as the basis for solving the problem of investigating the stationary flow over spatial carrying systems at supersonic conditions with sufficient accuracy. Figures 2; references 6.

#### Diffuser Evaluation Efficiency Parameters

927F0062N Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 50-56

[Article by B.S. Vinogradov, I.V. Babchenko]

UDC 533.697.3:533.6.011.5

[Abstract] High-head diffusers extensively used in air-breathing jet engines, wind tunnels, high-altitude test beds, gas dynamic experimental units, and gas dynamic lasers and their efficiency are considered; the diffuser head capability is defined as the ratio of static pressures while their efficiency - as a pressure recovery ratio, i.e., the ratio of the stagnation pressures on the diffuser outlet and inlet. The parameters used in published sources for estimating the diffuser head capability and efficiency are analyzed and formulas are suggested for linking the pressure recovery ratio and the drag coefficient; in addition, expressions are derived for analyzing the supersonic diffuser drag from known drag values of its component elements. Figures 4; references 6.

#### Airfoil Design Based on Velocity Chord Diagram Using Quasisolutions of Inverse Boundary Problems

927F0062O Kazan IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: AVIATIONNAYA  
TEKHNIKA in Russian No 4, Oct-Dec 90 pp 56-59

[Article by M.S. Galyaviyeva]

UDC 532.5

[Abstract] A common class of inverse boundary problems (OKZ) - the task of designing the airfoil on the basis of the flow velocity distribution on its surface, particularly in the case where the velocity is defined as a function of the Cartesian coordinate which changes along the unknown airfoil chord - is considered and a number of methods of solving these problems is discussed. An iterative method of designing closed-contour airfoils using a quasisolution of inverse boundary problems is analyzed. The problem is formulated for a planar steady-state potential flow of an ideal incompressible fluid over the unknown impermeable airfoil whereby it is assumed that the airfoil contour is closed and has no more than one corner point. The airfoil's leading edge coincides with the origin of coordinates while the  $x$ -axis is directed along the chord. Calculations are made on a unified system YeS-1045 computer (EVM). One minute of processor time was used to find the coordinates of 100 points inside the contour. The proposed iterative method of solving the inverse boundary value problem on the basis of the chord's velocity diagram makes it possible to design a closed-contour airfoil with minimal (in the sense of quasisolutions of the inverse boundary problem) initial data modifications. Figures 3; references 4.

**Determination of the Location and Orientation of Moving Objects Based on the Sensor Readings of Platformless Inertial Navigation Systems by Means of the Solution of Quarternion Equations of the Motion of Gyroscopic Systems on Onboard Computers**

927F0037A Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 4, Jul-Aug 91 (manuscript received 23 Oct 89) pp 3-12

[Article by Yu.N. Chelnokov, Balakovo]

UDC 531.383

[Abstract] The author of this article examines the problem of determining the geographic coordinates and parameters of the orientation of an object in inertial and rotating reference coordinate systems based on the running sensor readings of platformless inertial navigation systems. The said problem is solved by using an onboard computer to solve quarternion equations of the motion of gyro systems. The proposed approach is based on the familiar dynamic analogy of undisturbed gyro systems and two-component inertial navigation systems. Precession quarternion equations of the motion of a gyroscopic pendulum, bigryo vertical, two-rotor pendulum gimbal frame, three-dimensional gyro horizon compass, as well as complete quarternion equations of the motion of undisturbed gyro systems are used to solve problems of navigation and orientation by means of platformless inertial navigation systems. The approach considered herein makes it possible to propose new equations of the functioning of platformless inertial navigation systems possessing properties of equations of various undisturbed or corrected gyro systems. The said approach also makes it possible to use gyroscopy methods and results to construct algorithms for the operation of correctable platformless inertial navigation systems. The author concludes that using quarternions (Rodrigues-Hamilton parameters) makes it possible to construct algorithms that are convenient from a computation standpoint. In conclusion, the author notes that the error equations and the instrument errors of the proposed navigation problem solutions that are due to accelerometer and gyro tachimeter errors have a different structure than do the error equations and instrument errors of a conventional solution. This in turn may lead to a slower accumulation of instrument errors by platformless inertial navigation systems and warrants additional study. Figure 1; references 11 (Russian).

**Status and Prospects of Determining Location of Ships at Sea**

927F0042A Leningrad PROBLEMY MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN in Russian No 14, Jun 91 (manuscript received 10 Jan 88) pp 80-87

[Article by A.A. Kotyukh, deceased]

UDC 621.396.932

[Abstract] The first radio navigation systems, i.e., the Donsol and Konsolan, have been virtually completely

replaced by the more complex and comparatively high-precision radio navigation systems Loran, Dekka, and Omega. The Dekka radio navigation system is based on the hyperbolic method of determining ships' locations and consists of four stations that form a chain. More than 50 Dekka chains are currently in operation in regions with high ship traffic. Depending on the time of day, their range fluctuates from 250 miles (at night) to 400 miles (during the day). The Dekka radio navigation system is based on the phase difference method of location. The American radio navigation system Loran, on the other hand, measures both phase and time, which gives it a greater range. The Loran C has recently been replaced by the Loran A, which only measured time. The Loran C system uses a lower signal frequency, which gives it a longer range. With a maximal radiating power of 300 kW, a propagated wave signal may be received at a distance of 1,200 miles, a once-repeated spatial signal may be received 2,300 miles away, and a twice-repeated spatial signal may be received from a distance of 3,400 miles. Surface signals may be received with a degree uncertainty at distances of 1,200 to 1,800 miles and are not received beyond 1,800 miles. The Omega, an improved version of the British radio navigation system Delrac, became operational in 1976. The Omega system features an ultralong-wave difference-ranging design with phase synchronization of signals radiated by reference shore stations. All of the system's stations are equivalent and synchronized relative to worldwide time coordinates constituting a single global chain. In other words, the Omega radio navigation system is a hyperbolic system with an actual precision of 1-2 miles. The Omega system has a number of advantages over other long-range radio navigation systems. It is global; its signals can be received by aircraft, surface vessels, and submarines located on the surface or underwater; its stations use only three frequencies; and it is reliable in locating ships. The system is not without its drawbacks, however. Satellite navigation systems possess a number of advantages over radio navigation systems. They may be used throughout the year, 24 hours a day, and under all visibility conditions. They are more precise in locating ships, they operate on a global scale, and they eliminate the need to draw grids of isolines on sea charts or to address problems in fixing secondarily reflected radio waves. They are expensive, however, and require lengthy intervals between successive determinations of a ship's location (4 to 5 hours). The Tranzit and Tsikada satellite navigation systems will likely soon be replaced by the American system Navstar. In the current stage of the development of ship navigation, the navigator functions as an interface between various pieces of electronic navigation equipment and various pieces of control equipment. Electronic equipment provides quicker and better information than do conventional navigation instruments (sextants, compasses etc.). The sextant has been replaced by radio and satellite navigation systems and supplements radar navigation systems. While microprocessor-based navigation instruments provide obvious advantages over conventional navigation instruments, their potential for error is often not as readily recognized as is that of conventional instruments. The dangers of this fact may be minimized by using separate,



self-contained systems to supply navigation information as well. When the Glonass and Navstar satellite navigation systems become fully operational, it will be possible to sail ships entirely automatically based on courses entered into ships' memories. While automatic ship navigation is obviously different from automatic aircraft navigation, the experience that has been gained in developing the latter may be used as a basis for plotting the strategy of scientific and practical development of automatic ship navigation. Some possible avenues of development in this sphere include voice recognition systems for navigation computers and design of a system of backup and monitoring devices to ensure the correct operation of computer-based navigation systems. References 7 (Russian) Western.

#### **IR Radiometer With Optical Rectification in Nonlinear Crystal**

927F033D Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 3, Mar 91 (manuscript received 13 Oct 89) pp 54-56

[Article by Ye.S. Avdoshin, candidate of technical sciences, Tula Pedagogical Institute]

UDC 535.214.4:681.7.068

[Abstract] Pulse and continuous-wave CO<sub>2</sub> lasers operating in the infrared [IR] range are widely used in a number of scientific-engineering applications. The extensive use of CO<sub>2</sub> lasers has in turn necessitated the development of IR radiometers to monitor the characteristics of the IR radiation of these lasers at high powers up to 10<sup>9</sup> W/cm<sup>2</sup> at a wavelength of 10.6 μm. Conventional photoelectric instruments cannot be used to monitor the radiating power of CO<sub>2</sub> lasers because the high energy density of IR radiation results in irreversible damage in the photoreceiver elements and in the metal optical coatings used. In an effort to surmount this problem, the authors have developed a light-conducting IR radiometer based on the effect of optical rectification in a nonlinear tellurium crystal under the effect of high-power pulsed or continuous-wave radiation. The new IR radiometer includes a type ML-7 electrooptical modulator that is based on a GaAs semiconductor crystal and that is powered by a B5-24A high-stability power source with a constant voltage up to 100 V. The GaAs crystal has a refractive index of 3.3 and an electrooptical constant of 1.5 × 10<sup>-10</sup> cm/V. The hollow conical lightguide used in the radiometer is made of fused quartz that is capable of withstanding IR radiation with a radiating power up to 10<sup>10</sup>–10<sup>11</sup>. The inner surface of the cone has a 200-μm-thick reflective coating of Cu<sub>3</sub>Sn intermetallide alloy. The intermetallide coating has a microhardness of 560 kgf/mm<sup>2</sup>, and the minimal surface absorbance from the Cu<sub>3</sub>Sn equals 2.1% at a wavelength of 10.6 μm. The new IR radiometer features a nonlinear miter-cut tellurium crystal in the form of a 1-cm<sup>3</sup> right-angled cube with polished surfaces. The nonlinear crystal's faces are oriented with a precision of 1° relative to the x-axis. The remaining components of the new IR radiometer crystal are described in detail along with the procedure used to calibrate it. Tests conducted by using a CO<sub>2</sub> laser with a radiating power of 1 MW, pulse duration of 24-30

ns, and repetition frequency up to 100 Hz confirmed that the new IR radiometer measures the emissivity characteristics of IR radiation with a mean square deviation of 0.2%. Figures 2; references 7: 4 Russian, 3 Western.

#### **'Oblique' Scanning and Its Use in Television**

927F033A Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 3, Mar 91 (manuscript received 5 Mar 90) pp 34-37

[Article by S.A. Pokotilo, candidate of technical sciences, A.L. Snegirev, Irkutsk Military Aviation Engineering School, and G.I. Yasinskiy]

UDC 621.384.326

[Abstract] Multielement optical radiation detectors in the form of a linear series of sensors and intervals between them are widely used in aviation televisions. The line of sensors is generally oriented perpendicular to the scanning direction so as to permit parallel surface scanning in the television's field of view. The operation of such scanner configurations is often adversely affected by changes or random deviations in flight parameters. One way around this problem is to use the principle of "oblique" scanning. In essence, the line of sensors is turned by an amount equal to some established angle relative to the scanning direction. (This angle equals arctg (ab<sup>-1</sup>), where a is the dimension of the optical radiation detector sensor in the direction perpendicular to the sensor line's longitudinal symmetry axis and b is the distance between adjacent sensors.) This turning is accomplished by turning the optical radiation detector (which is connected to the cooling system by flexible lines) itself. Scanning using this sensor configuration is termed "oblique." The authors of this article present a series of basic relationships confirming the feasibility of using the principle of oblique scanning in aviation television. Specifically, they demonstrate the possibility of compensating for the effect of random flight parameter fluctuations on image quality by controlling the angle at which the line of optical radiation detector sensors are configured relative to the scanning direction, as well as by the controlling modulation transfer functions of the television's receiver channel by, for example, controlling the lens focal distance or the time constants of the individual sensors. Preliminary research results indicate that the oblique scanning may be used successfully to compensate for the effect of an aircraft's angular evolutions on image quality and to make autonomous measurements of the speed of a moving image. Figures 4; references 7 (Russian).

#### **Interference-Scanning Linear Motion Transducers With Heightened Sensitivity**

927F033B Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 3, Mar 91 (manuscript received 8 Feb 90) pp 47-50

[Article by V.N. Ilin, candidate of technical sciences, Electronics Institute, BSSR Academy of Sciences, Minsk]



UDC 681.7.069.32:681.785.57

[Abstract] One of the most important characteristics of linear motion transducers is the discreteness of their readout. One obvious way of increasing the resolution and discreteness of a linear motion transducer's readout is to reduce the period and increase the number of working diffraction orders. This path has its limitations, however, and its possibilities have for practical purposes been exhausted for the visible wavelength range. Another possible path is that of optical or electrical signal interpolation. In interference-scanning linear motion transducers, optical interpolation may be achieved by providing a rigid mechanical link between the measurement grid and diffracted beam reflector. The authors of this article have proposed and diagrammed a single-coordinate transducer with a rigid link between the measuring grid and one of the reflectors. The transducer is distinguished by its heightened motion sensitivity. As the grid and reflector move, there is an additional difference between the paths of the two beams, an additional phase change, and (consequently) an additional shifting of the bands per unit length. The said transducer is a base model that may be used in designing high-sensitivity transducers. The authors go on to describe and diagram a second transducer. In this transducer, both diffracted beams are working beams, and the change in the difference of the path in them is effected in the opposite phase. The main distinction of this second transducer is that an additional difference is created between the paths of the isolated diffraction orders subjected to interference on the grid. A mirror is used to correct the direction of propagation of the diffracted beams along the grid. This is accomplished by establishing a rigid mechanical link between both reflectors and the grid and by mounting them along its ends. A mirror is used to correct the direction of propagation of the diffracted beams along the grid. The components and operation of both of the proposed devices are described in detail, and analytical expressions are presented for use in calculating the cost of the interference bands. Not only do the two devices proposed possess a higher measurement precision than do transducers in which a diffraction grid serves as the measuring link, but they are also more precise than are interferometers that have been designed and constructed without signal spectrum transfer and electric photocurrent interpolation. Figures 2; references 2: 1 Russian, 1 Western.

**Using a Holographic Interferometer With a Hologram Beam Splitter To Research Nonstationary Processes**

927F033C Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 3, Mar 91 (manuscript received 29 Jan 90) pp 51-53

[Article by Ye.V. Kudryavkin, Ye.M. Platonov, candidate of physical and mathematical sciences, and A.F. Tuyev, Grodno State University]

UDC [681.787:778.38]:535.319

[Abstract] The authors describe and present experimental data regarding a holographic interferometer with several

lasers that is intended for use in studying rapidly occurring processes. The interferometer includes a hologram beam splitter that has been designed in the form of a set of five superimposed Bragg grids that have been written into the bulk of Mikrat LOI-2 photo emulsion. As the hologram was written, the angles ( $\theta$ ) between the object and reference beams were varied from 40 to 80°. The beam splitter was recorded at a radiation wavelength of 0.6328  $\mu\text{m}$ , and the measurements were made at the radiation wavelength of a ruby laser. The beam splitter was manufactured by using the process of photo processing with D-19 developer and subsequent bleaching. A maximum grid diffraction efficiency (when Bragg's diffraction condition was met) of 20% was achieved, and the scattering of the values obtained for the efficiency of the individual grids did not exceed 3%. The ratio of the intensities of the reference and object beams was approximately equal to 4. The dependence of the hologram beam splitter's diffraction efficiency on the angle of incidence of the reconstructing beam was determined; the width of the curves of the angle selectivity of the superimposed lattices ranged from 6 to 10°, decreased as  $\theta$  increased, and were in satisfactory agreement with the corresponding formula as published elsewhere. The new holographic interferometer with a hologram beam splitter was used to study a rapid plasma process formed by a high-voltage discharge pulse lasting about 15  $\mu\text{s}$ . Two OGM-20 lasers with selection of the lengthwise and transverse lasing modes served as a light source. The new interferometer made it possible to determine the density field, the shock wave velocity in different directions, and the moment at which the central symmetrical inhomogeneity was formed. A second set of experiments using four OGM-20 lasers was also conducted. The experiments performed confirmed that the new hologram beam splitter-based holographic interferometer makes it possible to study nonstationary processes in a wide range of time scales of the development of inhomogeneities while using different numbers of lasers as required for different sets of experimental conditions. The radiation losses in the said holographic system were minimal and were due mainly to the illumination engineering characteristics of the hologram beam splitter. Figures 4; references 6: 5 Russian, 1 Western.

**The Spectral-Time Method of Improving Fiber-Optic Image Quality**

927F0044A Leningrad

OPTIKO-MEKHANICHESKAYA

PROMYSHLENNOST in Russian No 2, Feb 91

(manuscript received 1 Dec 89) pp 3-7

[Article by O.V. Ageyeva, A.V. Yershov, and P.A. Mikheyev, candidate of technical science and laboratory head, and D.K. Satarov, doctor of technical sciences, State Optic Institute imeni S.I. Vavilov]

UDC 681.7.068

[Abstract] The authors describe a research study that was conducted to assess the feasibility of the spectral-time method of improving fiber-optic image quality. The new

method entails the spatiotemporal summation and averaging of the brightness, spectral, and geometric parameters of individual microquanta based on the method of spectral image decomposition and convolution and based on the technique of slow scanning. Together these two methods provide an improvement in image and color transmission quality. Combining the two methods also makes it possible to minimize fiber-optic systems' weight and size characteristics and improve their overall reliability. The new spectral-time method of improving fiber-optic image quality calls for supplementing the static spectral compensation circuit by adding an achromatic wedge that turns evenly around the optical axis. An experimental unit consisting of a master collimator, spectral prisms, lens, rotating achromatic wedge, fiber braid, and eyepiece was used to test the new method's effectiveness. During the experiment, ruled test targets of different contrasts were mounted in the system's field of view. The system's resolution for each test target was measured under the following conditions: without image processing, with implementation of the spectral method, with implementation of the slow-scanning method, and with implementation of the spectral-time method. To determine the optimal values of the gain in system resolution resulting from each successive method, the researchers took the measurements at different achromatic wedge angular rotation speeds. The tests conducted provided graphic evidence of the gains in fiber-optic image quality that may be derived by the proposed spectral-time processing technique. The optimal dynamic scanning characteristics, optical engineering characteristics, and spectral element dispersion for the new spectral-time method were determined, and the spectral-time method was discussed from the standpoint of the mechanism of the operation of the retina-brain system in humans. The authors conclude by stating that the spectral-time method of improving fiber-optic image quality may also be used successfully with other optical and optronic systems in which image reception, transmission, conversion, and indication are all accomplished by means of spatially digital elements (such as TV reception and transmission tubes, CCD-matrices, optronic converters, microchannel wafers, and multiplexed liquid crystal matrices). The efficiency of using the spectral-time method will of course depend on the values of the power, spectral, geometric, and noise parameters of the digital elements and on the extent of their mutual correlation. Figures 3; references 8 (Russian).

#### System To Form Large-Diameter Annular Electron Beam

927F0044B Leningrad  
OPTIKO-MEKHANICHESKAYA  
PROMYSHLENNOST in Russian No 2, Feb 91  
(manuscript received 15 Jan 90) pp 7-10

[Article by V.L. Yegorov, Ye.Ye. Khristich, and Yu.V. Chentsov, candidate of physical and mathematical sciences, State Optics Institute]

UDC 621.3.032.264

[Abstract] The authors worked to develop a new electron gun for use in forming an annular electron beam 150 mm

in diameter with an even distribution of current density throughout the beam's cross section. To reduce the overall dimensions and mass of the pump required, they decided to base their new system on the principle of electrostatic optics. They developed a program for the BESM-6 computer to calculate electrostatic fields and electron trajectories by means of the finite elements method. They then performed numerical computations of the fields and trajectories for several versions of the geometry of the electrodes of the electron pump that was to be used to form a large-diameter annular beam. After comparing several prospective design versions, the researchers proceeded to develop and test a pump with an electron prism formed by three grids. This made it possible to obtain a virtually even electron flux density in the plane of the anode within the confines of a ring with outer and inner diameters of 140 and 90 mm, respectively. At an electron density of 2 keV the gun provides current density between 0 and  $10^{-8}$  A/cm<sup>2</sup> in the beam on the test object. Figures 2; references 5: 3 Russian, 2 Western.

#### The Reflection Factors of Corner Reflectors

927F0044C Leningrad  
OPTIKO-MEKHANICHESKAYA  
PROMYSHLENNOST in Russian No 2, Feb 91  
(manuscript received 17 Nov 89) pp 13-16

[Article by S.V. Protsko, candidate of physical and mathematical sciences, and A.D. Titov, candidate of physical and mathematical sciences, Applied Physics Problems Scientific Research Institute imeni A.N. Sevchenko, Minsk]

UDC 681.7.062.7

[Abstract] The authors use the Jones matrix method to determine the reflection factors [R] of mirror and metallized retroaction corner reflectors as a function of the material with which they are coated and their radiation wavelength. Specifically, they examine mirror or coated (by either silver, aluminum, gold, or copper) corner reflectors whose three sides are in a  $\pi/2$ ,  $\pi/2$ ,  $\pi/s$  relationship (where  $s$  designates some even number between 2 and 20 inclusively) or else in a  $\pi/2$ ,  $\pi/3$ ,  $\pi/4$  or  $\pi/2$ ,  $\pi/3$ ,  $\pi/5$  relationship. The reflection factors of the said reflectors are calculated for light wavelengths of 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9  $\mu$ m. The reflection values presented were obtained by averaging with respect to the polarization azimuth of the incident radiation at each of  $2s + 2$ , 42, or 286 versions of reflection. The dependence of R on the polarization azimuth of the incident radiation was not found to be great. The dispersion of the values did not exceed 4%, and the dispersion of the values of R as a function of the version of reflection also did not exceed 4%. The deviations of R from the average value were found to increase as  $s$  increased. The reflection factors calculated led the authors to conclude that the reflection characteristics of the study metallized and mirror corner reflectors make them suitable for use in optical instrument making together with rectangular corner reflectors. Tables 2; references 7 (Russian).

**Measuring Radiation Losses in Optical Fibers by the Opticoacoustic Method**

927F0044D Leningrad

OPTIKO-MEKHANICHESKAYA

PROMYSHLENNOST in Russian No 2, Feb 91

(manuscript received 26 Jun 89) pp 16-18

[Article by S.A. Vinokurov, candidate of physical and mathematical sciences, and Ye.V. Zemtseva, State Optics Institute imeni S.I. Vavilov]

UDC 621.373.826:681.7.068

[Abstract] A number of works have recently been published regarding monitoring small amounts of absorption in optical fibers by the opticoacoustic method with microphone signal recording. The authors of the study reported herein have continued this line of research. Specifically, they set out to find a way of separately recording losses to absorption and scattering in optical fibers. First, they theoretically investigated the characteristic features of using a coaxial cylindrical opticoacoustic detector of small amounts of absorption in optical fibers. They showed that using such chambers makes it possible to increase the sensitivity of the opticoacoustic method several times over. Their computations further revealed that the chamber material would not greatly affect the signal developed: Calculations for chambers made of aluminum and glass yielded results that were within 1 to 2 percentage points of one another. They then proceeded to verify this theoretical conclusion by experimental research. They designed an opticoacoustic detector to record the light scattering of fibers in order to test their theoretical results. The working space was formed by two coaxial tubes. The inner tube was made of a material that was transparent for the required spectral range, and an absorbent with a low heat capacity was placed between the two tubes. The fiber was passed along the detector's axis outside its working space so as to keep the radiation absorbed by the fiber from participating in formation of the signal. Because the fiber was not in mechanical contact with the detector, it was possible to monitor the losses to scattering as the fiber remained in continuous motion. By replacing the conventionally used "thermally thick" optical chambers (in which the distance from the fiber to the chamber wall is at least equal to the length of the heat wave) with "thermally thin" chambers, they were able to increase the signal level. The gain in sensitivity derived from using a "thermally thin" chamber for the case of a cylindrical geometry with all other conditions being equal was found to amount to about two orders of magnitude. With a detector 18 mm long, respective coaxial tube diameters of 6.3 and 2.6 mm, a signal-to-noise ratio of 1, and a synchronous amplifier time constant of 1 s, the newly designed detector was found to have a threshold sensitivity of about  $5.5 \times 10^{-8}$  W. Its sensitivity was found to change only slightly as the frequency was varied between 12 and 280 Hz because both the signal and noise were in a relationship of about  $1/f$ . The authors thus succeeded in finding a way of increasing the sensitivity of separate recording of losses to absorption and scattering in optical fibers. Figures 3; references 5: 1 Russian, 4 Western.

**An Analysis of the Configuration of a Coherent Optical Spectrum Analyzer**

927F0044E Leningrad

OPTIKO-MEKHANICHESKAYA

PROMYSHLENNOST in Russian No 2, Feb 91

(manuscript received 2 Mar 90) pp 18-22

[Article by A.A. Berezhnoy, candidate of physical and mathematical sciences, A.I. Plakhotnik (Optical Mechanics Plant, Vologda), and Yu.V. Popov, candidate of physical and mathematical sciences, State Optics Institute imeni S.I. Vavilov]

UDC 621.391.244:535

[Abstract] The authors of this article performed a mathematical analysis of the characteristics of a coherent optical spectrum analyzer intended for use in processing a large array of electrical signals. Specifically, they derived a series of expressions to find the distribution of light intensity at the output of the study coherent optical processor for an arbitrary input array of signals  $f(t, y_i)$  obtained from such sources as an antenna array during the analysis of physical fields. For the sake of convenience, they assumed that all of the spectrum analyzer's functional elements were located either in the pupils or in ports of the optical train. This permitted the additional assumption that the distribution of the light fields in the pupils and ports is linked through a Fourier transform. The analysis revealed that the output spectral distribution of a coherent optical processor may be approximately represented in terms of three quantities: the spectrum of the input array of signals, the amplitude-frequency characteristic, and the response to the input harmonic signal. These quantities characterize the distortions introduced by the coherent optical processor's optical train. The authors further conclude that the same three quantities may also be used to approximately describe the operation of any functional node or light distribution in general by representing the light distribution in the form of a convolution of two functions multiplied by a third. One of these convoluted functions is the information signal (distribution), whereas the other two describe the functional node or optical train forming the light distribution. The analysis performed also demonstrated that when forming an image by a scanning system in coherent light by inputting information in a bar of modulators along a scanning line, it is best to transmit a high spatial frequency. When the information is input along a line of cells, it is best to transmit a low spatial frequency. Figures 3; references 6 (Russian).

**Quartz Wafers as Spectral Transmissivity Reference Standards**

927F0044F Leningrad

OPTIKO-MEKHANICHESKAYA

PROMYSHLENNOST in Russian No 2, Feb 91

(manuscript received 1 Feb 90) pp 23-26

[Article by V.G. Vorobyev, candidate of technical sciences and laboratory head, M.A. Kruglyakova, candidate of technical sciences, V.A. Nikitin, doctor of technical sciences, and V.A. Smirnov, State Optics Institute imeni S.I. Vavilov]

UDC 681.785.423.3:535.341

[Abstract] In a previous communication, two of the authors of the present study reported on their efforts to develop and manufacture a set of sector disks for use as transmissivity reference standards. In a continuation of this line of research, the authors have now turned their attention to the feasibility of using quartz wafers as transmissivity reference standards. Specifically, they studied quartz wafers made of KI quartz (in accordance with All-Union State Standard [GOST] 15130-86) with rated thicknesses of 0.5, 1, 2, 3, 4, 5, and 8 mm. Each of these thicknesses was measured with an error of  $\pm 0.001$  mm. Exact measurements of the transmissivity of each plate were taken by using a measurement and computation procedure that the authors describe in detail. Special steps were also taken to estimate any additional errors in measuring the transmissivity of each wafer due to such factors as temperature and beam geometry. The stability of the quartz wafer reference standards over time was determined by repeating the transmissivity measurements at 2- to 6-month intervals over a period of more than 2 years. The tests performed confirmed that sets of standard KI quartz glass wafers 0.5 to 8 mm thick may be used as reference standards reproducing transmissivities from 0.67 to 0.001. The said quartz wafers were proved acceptable for metrologic certification of infrared spectrophotometers with the following permissible photometric error ( $\Delta T$ ) limits:  $\pm 0.005$  or more when  $T \geq 0.1$ ,  $\pm 0.003$  or more when  $T \geq 0.01$ ,  $\pm 0.001$  or more when  $T \geq 0.003$ , and  $\pm 0.0003$  or more when  $0.003 T \geq 0.001$ . The main advantage of quartz wafer reference standards is that they may be used to check IR spectrophotometers based on different operating principles (including scanning and Fourier spectrophotometers) with only the following rather easy to satisfy requirements: selected spectral interval, up to  $12 \text{ cm}^{-1}$ ; wave number error,  $\pm 3 \text{ cm}^{-1}$ ; and differences in the temperatures at which the reference standards were certified and instruments are inspected,  $\pm 5^\circ\text{C}$ . Figure 1, tables 2; references 11: 10 Russian, 1 Western.

#### Optical Analyzer With Multiwedge Diaphragm for Direction Finders With Improved Precision

927F0044G Leningrad

OPTIKO-MEKHANICHESKAYA

PROMYSHLENNOST in Russian No 2, Feb 91

(manuscript received 18 Dec 89) pp 37-40

[Article by V.A. Afanasyev (deceased), candidate of technical sciences and department head, and S.Yu. Kachanova, Polyus (Pole) Scientific Research Institute, Moscow]

UDC 681.7.064.8:53.085.345

[Abstract] The authors of the research reported herein worked to develop a new and improved wedge-shaped optical analyzer for use in direction finders. The new optical analyzer would permit linear display of the coordinates X of a band-shaped light spot with a precision up to fractions of a percentage point given an uneven distribution of illumination of up to several tens of percentage points within the bounds of the spot's live zone. The new

analyzer is based on a light-transmitting diaphragm fashioned in the form of several equal, identically oriented wedges in the shape of a right triangle. These wedges are arranged such that their base legs form a continuous line segment while their side legs are parallel to the axis of the light spot's movements. The new multiwedge diaphragm was tested in a standard unit for studying the spectral characteristics of photodetectors. The five-wedge diaphragm tested was found to have a direction-finding error of about 0.5%, which is higher than the design value by a factor of 3 to 4. This fact was explained primarily by the uncorrected unevenness of the photodiode's sensitivity along the y coordinate and by microdefects of the slide used in the tests. On the basis of the test results obtained, the authors concluded that the new analyzer is entirely satisfactory for many practical purposes. Approaching the analyzer's design error levels will, however, undoubtedly require additional work to improve the technology used to manufacture the diaphragm and to find ways of reducing or completely eliminating the effect that an uneven distribution of sensitivity throughout the area of the photodetector has on the direction finder. The creation of special photodetectors with a sensitive area topology reproducing the shape of a multiwedge diaphragm appears very promising in this respect. Figures 4; references 4 (Russian).

#### Optimizing the Optical Train of an Interferometer in Conjunction With a Spectral Instrument

927F0044H Leningrad

OPTIKO-MEKHANICHESKAYA

PROMYSHLENNOST in Russian No 2, Feb 91

(manuscript received 26 Dec 89) pp 40-43

[Article by L.A. Gerasimova and G.V. Polshchikov, candidate of technical sciences, Precision Mechanics and Optics Institute, Leningrad]

UDC 681.785.57

[Abstract] Combining an interferometer with a spectral instrument makes it possible to use an interferometer in such additional physics research-related tasks as determining the dispersion of matter, refractivity, the angles and thicknesses of transparent objects, wavelengths and wavelength changes, and various inhomogeneities of an object. In light of this fact, the authors of this article examined the factors causing a change in the amplitude of the signal at the output of a combination interferometer-spectral instrument unit during the photoelectric recording of an interference pattern. Specifically, they considered such factors as the spectral dependences of the brightness of the radiation source, the transmission of the elements of the optical train, and the sensitivity of the radiation detector. They also examined ways of linearizing the output characteristic, including correcting the change in the radiant flux of the source in its working range by changing the feed voltage of the light source and, consequently, its color temperature. A method of optimizing the optical train of a combination interferometer-spectral instrument was also proposed. The said optimization method entails designing the elements of the optical train by proceeding from the condition of the constancy of the

output signal with only a minimal error. The feasibility of this new optimization method was tested by the authors in experiments involving measurement of the refractivity and thickness of plates of different thicknesses made of K-8 glass. The measurements taken by using a combination interferometer-spectral instrument optimized in accordance with the proposed procedure were compared with refractivity measurements of the same material taken on a GS-5 goniometer. The measurements were found to coincide with a precision up to  $1.2 \times 10^{-5}$ , which is within the goniometer's margin of error. Figures 4; references 4 (Russian).

#### Self-Aligning Optical Instruments for Angular and Linear Measurements

927F0044I Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 2, Feb 91  
(manuscript received 13 Mar 90) pp 43-46

[Article by S.A. Sukhoparov, doctor of technical sciences and professor, and I.N. Timoshchuk, Precision Mechanics and Optics Institute, Leningrad]

UDC 681.783.2

[Abstract] The authors of this article examine three different types of self-aligning optical instruments for use in taking angular and linear measurements. First, they present a concise overview of the existing types of leveling instruments with a self-aligning line of sight. They diagram and explain the operation of a leveling instrument with a compensator. Next, they turn their attention to theodolites with compensators. They diagram the optical train of the sighting telescope of a theodolite with a self-aligning line of sight in which a plane mirror that is suspended on a hinge and located horizontally at half the focal distance of the lens is used as an optomechanical compensator. Special attention is given to the characteristic features of the optomechanical scheme of such sighting telescopes. In the third and final section of this overview, the authors diagram and discuss the operation of a self-aligning cathetometer. Each of the instruments examined adheres to the principles of spatial invariance. The authors substantiate the spatial invariance of each of the individual instrument designs discussed. Figures 5; references 6 (Russian).

#### Apochromatic-Collimator Lens

927F0044J Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 2, Feb 91  
(manuscript received 6 Dec 89) pp 47-49

[Article by M.A. Ostrovskaya, candidate of technical sciences, A.S. Manina, T.P. Grimm, T.Ye. Balashova, and T.K. Krupina, State Optics Institute imeni S.I. Vavilov]

UDC 681.777.2

[Abstract] Standard collimator lenses (such as the OSK-1 and OSK-2) are two-lens apochromatic lenses possessing a broad secondary spectrum. In many cases, such as when an optical transmission function and geometric aberrations are being measured or when the quality of a telescope system is being evaluated, this chromatic aberration

injects a noticeable error into the measurement results. In view of this fact, the authors of the study reported herein worked to develop a new long-focus collimator lens with apochromatic correction that could replace standard collimator lenses. The new apochromatic collimator lens is made of three types of glass (PK50, KZFSN5, and SF60) arranged in a five-lens configuration. The new apochromatic collimator lens has a focal distance of 3,028 mm and a diameter of 200 mm. The new lens is capable of creating an image that is virtually of diffraction quality. Tests demonstrated that in the case of a lens 200 mm in diameter, the wave front deformation at the center of the field is in full compliance with the requirements that have been established for collimator lenses (an average quadratic wave front deformation of  $\sigma = 0.04\lambda$  and  $\lambda = 633 \mu\text{m}$ ). Decreasing the lens diameter to 150 mm results in a mean quadratic wave front deformation in the center of the field of  $\sigma = 0.02$ . The new lens is now being used in test equipment. Figures 4, table 1; references 2: 1 Russian, 1 Western.

#### OPTIDAM—A Data Bank on the Optical and Spectral Properties of Optical Materials

927F0044K Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 2, Feb 91  
(manuscript received 9 Jan 90) pp 49-51

[Article by G.T. Petrovskiy, corresponding member USSR Academy of Sciences, V.N. Morozov, candidate of physical and mathematical sciences, and Ye.V. Smirnova, candidate of physical and mathematical sciences, State Optics Institute imeni S.I. Vavilov]

UDC [535:666]:681.3

[Abstract] The State Optics Institute imeni S.I. Vavilov has created an automated information retrieval system based on the OPTIDAM (an acronym for OPTicheskiye DAnnyye Materialov [optical data on materials]) data bank. The OPTIDAM data bank includes basic information about the key physical and chemical properties of materials and substances used in optical instrument making: optical glasses, optical crystals, metal coatings, etc. The OPTIDAM system is designed in two parts—a functional part and a support part. The functional part includes a data base containing information about materials; metrologic, reference, and bibliographic data; and data on the distribution of information about specific materials and processes in the system's data base. The support part provides data base organization and maintenance support, data base software, organizational support, and information required to assess the reliability of the information used to compile the data base (this information is referred to as metrologic support). This information may be used in making precision measurements of such characteristics of optical materials as refractivity and dispersivity in various regions of the spectrum, anisotropy of optical properties, the mechanical properties of glasses and crystals, magneto-optical and thermo-optical characteristics, luminescence characteristics, radiation stability, photochromy, and chemical stability. The information provided in the OPTIDAM data base is illustrated by way of

a standard entry (the entry for STK-8 glass). A set of utilities is also available for use in outputting information about various characteristics of objects, and programs have been created to describe the optical properties of composite objects. The system has been proposed for inclusion in a unified countrywide data bank. References 14: 11 Russian, 3 Western.

### **Determining the Optimal Refractivity Values of Antireflective Coatings**

927F0044L Leningrad

OPTIKO-MEKHANICHESKAYA

PROMYSHLENNOST in Russian No 2, Feb 91

(manuscript received 18 Jan 90) pp 57-60

[Article by R.K. Mukhamedov, State Institute of Applied Optics, Kazan]

UDC 681.7.064.454:535.314

[Abstract] The author of this article has presented a simple method of determining the optimal values for the refractivity of the layers of an interference coating when the thicknesses of the layers and specified values of their spectral ranges in which high transparency must be provided are known. The basic formulas used to make this determination has been derived by proceeding from P.G. Kard's approximate formulas for calculating the spectral characteristics of an interference coating. The use of the new method and equations is illustrated by way of several examples. The new method also yields satisfactory results in the case where antireflective coatings must be applied in an area consisting of multiple wavelength bands. The new method may be used to determine the optimal refractivities of any number of layers in a system given sufficient transparency of the initial structure in the specified spectral regions. Figures 2, table 1; references 14: 12 Russian, 2 Western.

### **A Vibration-Thermal Method of Obtaining Finely Dispersed Cerium Dioxide**

927F0044M Leningrad

OPTIKO-MEKHANICHESKAYA

PROMYSHLENNOST in Russian No 2, Feb 91

(manuscript received 1 Mar 90) pp 69-71

[Article by M.I. Levin, candidate of technical sciences, Ye.A. Bondarenko, N.L. Nazarova, S.S. Kulagina, and Ye.Ye. Belousova, State Scientific Research Institute of the Rare Metal Industry, Moscow]

UDC 681.7.043:661.865.562.2

[Abstract] The authors of the study reported herein examined a combination vibration-thermal method of producing finely dispersed cerium dioxide. The studies were conducted in a unit consisting of a vertical electric furnace that contained a multistage plate-type vibratory contact device that in turn included seven plates. Each had a height of  $2 \times 10^{-2}$  m and an area of  $28 \times 10^{-4}$  m<sup>2</sup>. The starting material (cerium (III) carbonate) was loaded and unloaded continuously and was granulated as it was mixed. Moist granules were dried out and broken up to form a powderlike material that was then subjected to

high-temperature and mechanical treatment. The sizes and shapes of the particles formed were studied on a transmission electron microscope with an accelerating voltage of 80 kV. The starting cerium carbonate particles had a prism shape 0.5 to 3  $\mu$ m long and 0.5 to 0.14  $\mu$ m wide. Heating these particles to 250°C resulted in a mixture consisting of cerium carbonate and cerium oxide particles that maintained the shape of the starting carbonate particles. At 400°C the product was characterized as cerium oxide preserving the shape and dimensions of the starting carbonate. At 740°C, separation of cerium oxide microcrystals began thanks to the vibratory wear of the material and a decrease in its particle strength. Total destruction of the particles at 940°C resulted in a product consisting solely of microcrystals 0.1 to 0.3  $\mu$ m in size. The polishing capability of the resultant particles was confirmed by using them to polish 75-mm-diameter glass lenses. The most stable polishing suspension was produced by using cerium oxide particles processed at 920-940°C. The high polishing capability observed at 740°C was explained by the particles' enhanced abrasiveness; however, the quality of polishing when using the latter particles remained low. Figure 1, table 1; references 6 (Russian).

### **The Surface Properties of Phosphate Glass Treated in Ammonia Medium**

927F0044N Leningrad

OPTIKO-MEKHANICHESKAYA

PROMYSHLENNOST in Russian No 2, Feb 91

(manuscript received 5 Jan 90) pp 71-72

[Article by I.N. Yashchishin, doctor of technical sciences, professor, and department head, O.I. Koziy, Lvov Polytechnic Institute, and O.S. Shchavlev, doctor of technical sciences, State Optics Institute imeni S.I. Vavilov]

UDC 666.11.01

[Abstract] Phosphate glass would be a promising base material for use in obtaining special-purpose optical materials were it not for the fact that the performance characteristics of phosphate-based glasses do not meet the requirements set for modern instrument making. In an effort to surmount this problem, the authors of the study reported herein examined the effect that thermochemical treatment in an ammonia medium would have on the performance properties of the surface of barium phosphate glass. Specifically, they examined the effect that heat treatment of types GSL-22 and GLS-32 glass at temperatures of 450, 500, and 550°C would have on the chemical stability, wettability, and microhardness of the surfaces of the said glasses. Heat treatment in ammonia of the two glasses rendered them hydrophobic. After heat treatment, the wetting contact angle of the glass more than doubled. Heat treatment in ammonia increased the chemical stability of the study glasses by a factor of 3 to 4 and increased their microhardness by 40 to 50%. The optimal temperature of the said heat treatment was found to be between 450 and 500°C. Figure 1, tables 2; references 6 (Russian).

**A Method of Allowing for Errors When Inspecting the Thicknesses of the Layers of Interference Coatings**

927F00440 Leningrad

OPTIKO-MEKHANICHESKAYA

PROMYSHLENNOST in Russian No 2, Feb 91

(manuscript received 13 Oct 89) pp 66-68

[Article by I.Sh. Baygildin, candidate of technical sciences, State Institute of Applied Optics, Kazan]

UDC 681.7.064.45:535.24

[Abstract] A photometric technique based on fixation of the extreme points of transmission or reflection is the most common method of inspecting the thicknesses of individual layers of interference coatings as they are applied.

The method frequently results in measurement errors in view of the imprecision in fixing the point of the extreme points. In an effort to remedy this situation, the author of this article worked to derive a series of exact formulas that could be used to determine the path of the transmission curve and errors arising when the individual layers of interference coatings are inspected. A method of correcting the check wavelengths that makes an allowance for these errors is also presented. The author has compiled a program (in BASIC) for Elektronika T3-29M computers that may be used to find check wavelengths that can be used to compensate for the errors resulting from the redusting that occurs when interference coatings and the photometric technique is used to inspect them. Figure 1, tables 2; references 7 (Russian).



**Lowering Stresses and Strains of Thick-Walled and Thin-Walled Fault Localizing Structures in Nuclear Power Plants**

927F0046B Moscow *ENERGETICHESKOYE STROITELSTVO* in Russian No 5, May 91 pp 29-31

[Article by V.A. Malashonok, engineer, Ye.P. Kharitonov, engineer, and A.N. Zhmotov, engineer, Scientific Research and Institute of Power Equipment Installation Engineering and Technology]

UDC 621.311.25:621.039.584:539.4

[Abstract] The fault localizing structures which confine radioactive materials within the reactor housing of a nuclear power plant in case of an accident are two hermetic thick-walled structures, a main sluice and an emergency sluice, built according to the same standard design for all nuclear power plants. During their installation they are often found to have cracked welded joints, some up to 6 m long cracks having been found in sluice casings for Balakovo, Smolensk, Kalinin, Kozloduy (Bulgaria) nuclear power plants, and the Voronezh nuclear heat supply plant. A combination of several factors has been found to lower the mechanical strength and cause brittle fracture of these structures: 1) large flaws in sluice casing casting; 2) closely spaced welds with large metal buildup within small areas and especially so near the hermetic zone of the emergency sluice, 3) wide gaps in the joints formed as necessary tolerances on clearance between joined parts need to be maintained during the intricate assembly process. These factors and their influence on the behavior of such structures are analyzed, for the purpose of avoiding development of unsafe cracks by lowering the levels of stress and strain in the critical regions. On the basis of such an analysis, there has been devised a double sheathing preparation and installation technology. It involves use of a frame formed by two channel beams or I-beams and welded to the bulkhead (stainless steel) between the two sheaths on the side of the hermetic zone, either parallel or perpendicularly to the adapter strips, immediately after spot welding of the sheaths and inspection of the resulting butt joint. The technology involves also removal of detected flaws in castings, inspection of the edges of welds by physical methods, setup of rim and collar, control assembly of sluice casing with backing strip for measurement of collar and backing strip diameters, machining the collar so as to ensure the specified clearance between collar and backing strip, high-temperature annealing the collar for stress relief after it has been welded on, removal of defects in welds, and mounting the flange facilitated by splitting it into three or four sectors. It is noted that all these proposed operations are makeshift measures only and do not guarantee the required reliability, which is more likely attainable only by a complete redesign of the sluice and, most importantly, by a better spacing of welds. Figures 1.

**Estimating Stressed State of Containment Structure in Nuclear Power Plant During Start-Up and Normal Operation**

927F0046C Moscow *ENERGETICHESKOYE STROITELSTVO* in Russian No 5, May 91 pp 53-54

[Article by A.P. Kirillov, doctor of technical sciences, All-Union Scientific Research Institute of Technological

Norms Planning and Engineering (?) (VNIINTPI) at USSR State Committee for Construction, E.Ya. Bagriy, candidate of technical sciences, V.N. Zavyalov, engineer, S.V. Kulakov, candidate of technical sciences, and A.L. Kukush, engineer, Makeyev Institute of Construction Engineering]

UDC 621.039.584

[Abstract] The distribution of stresses in the containment structure (reinforced concrete) for a nuclear power plant was estimated during the design process, so as to ensure the necessary reliability with an economical use of materials. For calculation of its changing stressed-strained state over a period of time including start-up and normal plant operation, the structure was treated as a monolithic composite of a hollow vertical cylinder and a shallow spherical dome. With the concrete under biaxial compression, the structure was considered to behave as an elastic one during preliminary stress buildup only and creep of concrete then to occur during 3 months of normal operation. Meridional and circumferential bending moments were calculated, assuming a 20°C constant inside temperature. An analysis of the data indicates that taking into account creep of concrete under biaxial compression yield more accurate estimates so that the material content in such a structure can be minimized accordingly without a decrease of reliability. Figures 2; references 5.

**Method of Designing Reinforced-Concrete Containment Structure for Nuclear Power Plant To Withstand Impact by Falling Airplane**

927F0046E Moscow *ENERGETICHESKOYE STROITELSTVO* in Russian No 5, May 91 pp 56-60

[Article by A.S. Zalesov, doctor of technical sciences, and V.I. Pugachev, candidate of technical sciences, Scientific Research Institute of Concrete and Reinforced Concrete, USSR State Committee for Construction]

UDC 621.039.584

[Abstract] A method of designing a reinforced-concrete containment structure for a nuclear power plant so that it will withstand an extremely severe dynamic load such as impact by a falling airplane is proposed, the aim being to design an economical as well reliable such structure. The method utilizes the results of extensive studies concerning plastic deformation of the principal load carrying members: concrete, steel sheaths, longitudinal and transverse steel rods. It takes into account the inertia forces attending formation of the dislodgment cone and aims at maximizing their beneficial effect in opposing the contact forces at the instant of impact. The design according to this method involves an analytical solution of the differential equations of motion for such a structure under a vertical downward impact load, namely their integration over each segment of the corresponding load-deflection curve between limits within which the stiffness of the structure remains constant. Design calculations by this method were made with the aid of an MK-54 programmable calculator, for a typical impact force of 300 kN acting within a zone 1.12 m in diameter. For a more extensive design analysis



and optimization by variation of parameters and comparative evaluation of design variants, however, the algorithms of this method have been programmed in BASIC language for an IBM PC/XT or PC/AT computer. The results of that analysis indicate that a 1.1 m thick containment wall will ensure the necessary strength of most design variants, the optimum variant then being the one ensuring maximum reliability with the least number of assumptions and constraints. Figures 3; references 4.

#### **Estimating Reliability of Hermetic Sheaths for Nuclear Power Plant Equipment by "Events Tree Diagram" Method**

927F0046D Moscow *ENERGETICHESKOYE STROITELSTVO in Russian* No 5, May 91 pp 54-56

[Article by V.I. Klyashchitskiy, candidate of technical sciences, All-Union Scientific Research and Planning Institute of Nuclear Power Equipment]

UDC 621.039.584

[Abstract] A simple "events tree diagram" algorithm of estimating the reliability of a hermetic protective sheath for nuclear power plant equipment is constructed, with a nuclear accident (probability  $P = 0.001-0.001$  at the present state of the art) as the initial event. This event, accompanied by an unsafe temperature rise after loss of coolant and resulting in either retention or loss of stability, is followed by failure of the first stay and then failure of the second stay (probability of stay failure  $P = 0.05$ ). As the load continues to rise, in the meantime, the hermetic protective sheaths can fail either earlier under excessive fiber strain or later under excessive membrane strain. There is no need to continue the tree of events beyond sheath failure. The probability indicator of its failure (reciprocal of safety factor) according to each of the two strain criteria are calculated according to standard formulas (USSR, Czechoslovakia, France, USA), whereupon the consequences of preceding events are classified on this basis in terms of retention or loss of hermeticity. References 5.

#### **Investigation and Operation of the SPP-1000 Moisture Separator/Reheater Unit of Unit No. 1 at the Zaporozhye AES**

927F0039B Moscow *TEPLOENERGETIKA in Russian* No 4, Apr 91 pp 43-46

[Article by V.L. Mukhachev, V.Yu. Pikus, O.I. Nazarov, and V.P. Filimonov, candidates of technical sciences, V.L. Lundin and V.A. Buzlukov, engineers, V.N. Grebennikov, candidate of technical sciences, and N.G. Yeliseyev, engineer, VNIAM, Yuzhtekhenenergo, Podolsk Machine Building Plant, and Zaporozhye AES]

UDC 621.311.25:621.039.621.928

[Abstract] The authors of this article report the results of a study of the SPP-1000 moisture separator/reheater unit of the No. 1 unit of the Zaporozhye Nuclear Power Plant. Unlike previous studies, which have been based entirely on indirect measurements, the study reported herein is based on direct measurement of the moisture field both in the heated steam receiver and directly after the SPP-1000

operating in the No. 1 unit's turbine plant. The said turbine plant (a K-1000-60/1500-2) is outfitted with four SPP-1000 moisture separator/reheater units. A special experimental monitoring system was installed to monitor the operating conditions of the SPP-1000. The moisture field and metal pipe surface temperature measurements were taken by nonstandard measuring instruments developed by the VNIAM. All remaining measurements were taken by using standard instruments. The study was conducted at different turbogenerator load levels in the interval from 400 to 950 MW. The studies performed indicated that the temperatures of the flows of heating and heated medium in the SPP-1000 are close to their design levels, whereas the temperature of superheated steam in the unit is several degrees above the design value. The moisture of the flow throughout the cross section of the heated steam feed receiver was found to be uneven. At loads between 0.9 and 0.95 of the rated load, the moisture level was found to vary only weakly in the nucleus ( $y \approx 1\%$ ) but to rise sharply near the wall. The local moisture values throughout the moisture separator/reheater unit cross section beyond the separator unit were found to vary by individual operating mode and to exceed the design values. The data obtained confirm the need to take measures to improve the moisture separator/reheater unit's operating conditions. Given the existing piping of the SPP-1000 and considering the phase distribution characteristics discovered to exist in the heated steam feed receiver, one possible direction in which to proceed is to set up forced separation of the flows with different moisture contents. Steam can then be bled from the near-wall annular zone (where the moisture content is elevated) and diverted for other uses. This may be done at a rate equal to or greater than the average velocity of the main flow. Figures 4; references 6: 5 Russian, 1 Western.

#### **Commercial Tests of an Automatic Discharge System for V-1000 Reactor Unit**

927F0039 Moscow *TEPLOENERGETIKA in Russian* No 4, Apr 91 pp 38-43

[Article by O.N. Pavlysh, candidate of technical sciences, and A.T. Sokolov, engineer, Yuzhtekhenenergo]

UDC 621.311.25:621.039

[Abstract] A new automatic discharge system for V-1000 reactor units was subjected to commercial tests at the Rovno Nuclear Power Plant. The said unit is a standard unit with a V-320 water-moderated water-cooled reactor, an LMZ K-1000-60/3000 main turbine, and a double-loop heat flow diagram. The said heat flow diagram includes a low-pressure regeneration system, two deaerators, two feed turbopumps, a high-pressure regeneration system, and a steam generator feed unit consisting of four main and four start-and-stop feed control valves. The design of the new automatic discharge system for a standard reactor unit was developed by the Kharkov department of the AEP [not further identified] based on Kaskad-2 equipment produced by the Moscow Thermal Automation Equipment Plant [MZTA] and UKTS [not further identified] of the Elva Scientific Production Association in accordance with

requirement specifications developed by the All-Union Heat Engineering Institute imeni Dzerzhinskiy. The new system to control turbine power and pressure is an electrohydraulic system consisting of fast- and slow-acting control loops. A preliminary round of tests was conducted at the South Ukraine and Rovno Nuclear Power Plants. These tests demonstrated the need to make changes in the configuration of the main control elements of the secondary loop and in the safety interlock system switching the auxiliary header to steam from the turbine steam bleeds. Various adjustments in the secondary loop were made, including changes in the operation of the control elements of the loop's steam dump and the addition of elements to control the pressure in the auxiliary header and in the deaerator. After the said changes, the unit was subjected to a complete battery of tests. These tests included disconnecting one of two operating feed turbopumps and disconnecting two of the four operating main circulating pumps. The transient processes of the tests were close to the dynamic processes occurring when one feed turbopump is disconnected. The tests conducted

demonstrated that the new rapid discharge system is capable of effectively discharging a reactor unit and maintaining its key technological parameters within allowable limits. The tests also revealed that the quality of the transient processes occurring in a V-1000 reactor unit may be further improved by using improved automatic control systems and simultaneously increasing the reactor discharge rate of the power control element. One way of accomplishing this is to connect two groups of control elements to the power control element and to make their movement parallel. This would make it possible to increase the design operating efficiency of the power control element both during accelerated reactor discharge and when discharging a reactor with a power level below 75% of the rated level. The commercial tests conducted thus confirmed the feasibility of using the new automatic reactor discharge system in 1000-MW reactor units as a way of increasing dynamic stability in the event of unscheduled shutdowns of basic mechanical equipment. Figures 3; reference 1 (Russian).

**High-Reliability Electric Power Transmission Lines**

927F0046A Moscow *ENERGETICHESKOYE STROITELSTVO* in Russian No 5, May 91 pp 21-25

[Article by T.B. Zaslavskaya, candidate of technical sciences, Siberian Department, All-Union Design and Surveying Institute for Electric Power Networks, and D.T. Zhanayev, candidate of technical sciences, Tolyatti Polytechnic Institute]

UDC 621.315.17

[Abstract] A design of 4-conductor 110 kV and 220 kV overhead electric power transmission has been developed which ensures a reliability almost as high as that of two-circuit 6-conductor lines while featuring much lower power losses and a better material economy. The fourth conductor can be used either as a standby automatically or manually connected when phase-to-ground short has not been cleared after single-phase automatic reclosure, or as a reserve for operation after faults and during repairs only, or as an auxiliary parallel conductor connected into any of the three phases for normal operation. In the last case it is not transposed, while the other three conductors are appropriately transposed at least every 100 km. Towers and substations have also been designed for each application of the fourth conductor, with necessary automatic control and protection for the entire line. Nominal performance and maintenance characteristics of such 110 kV and 220 kV lines with a fourth conductor range from equal to much better than those of single-circuit lines with three-phase control, single-circuit lines with phase-by-phase control, and two-circuit lines with common support towers for all six conductors. In terms of unit cost (kilorubles/km), such a 110 kV 4-conductor line ranks intermediate between a less costly conventional single-circuit 3-conductor line and more costly conventional two-circuit 6-conductor line. Insulation is a major high-cost item in a 4-conductor line. Figures 3; tables 3; references 16.

 **$J_{1C}$ —An Indicator of the Performance Reliability of TES Steam Lines**

927F0036A Moscow *PROBLEMY MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN* in Russian No 4, Jul-Aug 91 (manuscript received 21 Jan 87; after revision 22 Sep 88) pp 51-56

[Article by A.A. Islamov]

UDC 621.181:669.018.2

[Abstract] At the present time, the main indicator of the performance reliability of a TES steam line is its accumulated residual stress. Practice has demonstrated, however, that accumulated residual stress is not always a reliable indicator. This is because existing fracture after protracted creep is brittle in nature and in many cases is not preceded by plastic deformation. In view of this fact the author of the study reported herein examined the feasibility of using the indicator  $J_{1C}$ , i.e., the static crack resistance of the metal of which a steam line is made, as an indicator of TES steam line performance reliability. The studies were performed on specimens of 12Cr1MoV steel in its initial stage and on specimens cut from nine industrial steam lines that had been in service for various amounts of time (up to 170,000 hours) at a number of TETs throughout the country. To compensate for differences in the conditions under which the different specimens operated, the author adjusted the service time of each specimen for a single level of working stress (69.6 MPa) and single temperature (540°). The tests were conducted at room temperature on knife-edge specimens with a cross section of 15 x 20 mm and with a unilateral edge crack based on a three-point bending scheme at a stress rate of 8 to 10<sup>-2</sup> mm/s. After 170,000 hours of service, the value of  $J_{1C}$  for the test specimens decreased from 170.0 to 54.0 kJ/mm<sup>2</sup>. In the first 48 hours, however, the value of  $J_{1C}$  remained constant and even increased somewhat. The tests performed demonstrated that while the standard mechanical properties characterizing steel (working stresses) remain virtually unchanged after 170,000 hours of operation,  $J_{1C}$  decreases by a factor of 3. The evolution of pipe steel's structural stage and phase composition is also shown to be linked with  $J_{1C}$ . The author proposes a technique for using the change in  $J_{1C}$  and Ye.M. Morozov's test to estimate the residual life of steam lines. In essence, four expressions presented by the author are used together with graphic-analytical techniques to estimate steam line durability. In a test case, the proposed estimation technique placed the estimated life of a test steam line at 58,000 hours. It actually fractured after 69,500 hours of service. This result indicates the conservatism of the proposed method, which provides maximal insurance against possible brittle fracture. Figures 2, table 1; references 10: 9 Russian, 1 Western.

**Joint Scientific Council of the USSR Academy of Sciences on the Comprehensive Topic Machine Building**

927F0035C Moscow PROBLEM

*MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN in Russian No 4, Jul-Aug 91 pp 118-120*

[Article by V.A. Dubrovskiy]

[Abstract] The Joint Scientific Council of the USSR Academy of Sciences on the Comprehensive Topic Machine Building held a working session together with USSR Academy of Sciences scientific councils on the following: problems of machine sciences and engineering processes, the problem of reliability and life in machine building, robotics and automation of manufacturing, and the mechanics of structures made of composites. The executive committee for business affairs of the International Federation for the Theory of Machines and Mechanisms in the USSR also participated. The scientific council prepared a new text of the document "Main Directions for the Development of Natural and Social Sciences Regarding Problems of Machine Building for 1991-1995 and for the Period up to the Year 2000" and continued its scientific-methodological direction of the program "Increasing the Reliability of Machine-Man-Environment Systems." Thirty-three reports were presented by candidates for either full membership in the USSR Academy of Sciences or corresponding member status. Sections were held on each of the aforementioned problem areas, and reports were presented in each. The following are among the topics discussed in the reports: the principles of designing high-reliability, high-capacity machines and devices based on multicriterial optimization of reliability indicators; the creation of fundamentally new crushers and vibratory sieves for use in energy-saving waste treatment technologies; two-phase and evaporation systems to control temperature aboard spacecraft; prototypes of manufacturing robots to move along vertical and sloping surfaces and along ceilings; development and introduction of an unrivaled nonflammable nontoxic glass-reinforced plastic (miniplen); continuation of research to increase machine and machine component reliability by modifying surface layers and applying new coatings to them; development of the VT-50M x-ray microtomograph; development of a cellulose-based asbestos-free friction material for use in manufacturing clutches for use in passenger cars and in the machinery used in light industry; a lubrication system for the friction nodes of power equipment that reduces component wear by 20-25% and increases life by a factor of 5 to 10; development of a method of designing adaptive electrohydraulic drives for mobile robot systems; and development of a new polymer elastic with increased frost and wear resistance for use in sealing technology.

**Using Ion Implantation To Strengthen Machinery Components**

927F0035B Moscow PROBLEM

*MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN in Russian No 4, Jul-Aug 91 (manuscript received 8 Oct 90; after revision 20 Mar 91) pp 80-89*

[Article by M.I. Guseva, Moscow]

UDC 539.389.2:660.018.86

[Abstract] Ion implantation is a powerful tool in modifying the surface properties of construction materials. Success in using ion implantation to increase microhardness, durability, corrosion resistance, and plasticity was first achieved in the early sixties. The ion implantation technique is currently being developed to effect purposive changes in the mechanical, tribological, chemical, corrosion, catalytic, optical, superconductive, emission, and other surface properties of various materials. The first generation of Soviet ion implantation units (the ILU type) generated comparatively high currents (10 to 15 mA) at ion energies (of practically all elements) up to 100 keV. ILU ion implantation units are still being used today to modify metal and alloy surfaces. They are capable of covering a target area of 100 x 200 mm<sup>2</sup> with an irradiation dose of 10<sup>17</sup> cm<sup>-2</sup>. The USSR also manufactures the Delta ion implanter. It is a two-beam accelerator. One ion beam provides separation of ions by mass, whereas the other beam is a divergent beam without separation. The Vita accelerator, whose ion beam covers the greatest area, is used for cleaning surfaces, applying coatings, and ion beam mixing. This review provides numerous examples (both foreign and domestic) of the effectiveness of ion implantation in increasing the mechanical properties of construction materials and illustrates how the ion implantation method makes it possible to design and construct profiles of a specified configuration by varying irradiation dose and ion energy. The Vita accelerator, which was developed at the Atomic Energy Institute imeni I.V. Kurchatov and which is series-produced by the Molniya MPO may be used to subject machinery components to implantation with ions of virtually all elements at a treatment speed of 3 to 10 s/cm<sup>2</sup>. Studies of the economic effects gained by the ion implantation method of treating machinery components in Great Britain, the United States, the USSR, and a number of other countries have demonstrated that at this treatment speed, the ion implantation method is economically comparable with conventional treatment (casehardening). Figures 4, table 1; references 36: 24 Russian, 12 Western.

**Developing Motor Vehicle Designs and Improving Their Reliability**

927F0035A Moscow PROBLEM

*MASHINOSTROYENIYA I NADEZHNOСТИ MASHIN in Russian No 4, Jul-Aug 91 (manuscript received 1 Nov 90) pp 14-24*

[Article by A.I. Titkov, Moscow]

UDC 629.017

[Abstract] More than 80% of all freight transport and 50% of all passenger transport in the USSR is by motor vehicle. From the standpoint of vehicle output, the USSR automotive industry occupies a leading spot not only in Europe but throughout the world. The main problem is that for many years, development of the USSR automotive industry has been one-sided. Priority has continually been given to vehicles with a payload of 4.5 to 8 tons, whereas production of motor vehicles with smaller (0.4 to 1.5 t) and

larger ( $>8$  t) payloads has been far too low. The range of passenger cars manufactured has also been extremely one-sided: Nearly 1.1 of the 1.3 passenger cars produced have been compacts (models VAZ, ZALK, and IZh). The strategy developed by the Ministry of Automotive and Agricultural Machine Building [Minavtoselkhoz mash] for the economic and social development of the automotive sector reflects two trends. The first, which may be termed the extensive development path, calls for dramatically increasing construction of new automotive plants and boosting the number of motor vehicles produced. The second, i.e., the intensive development path, calls for increasing expenditures on scientific research and experimental design developments focusing on increasing motor vehicle durability and reliability and for increasing expenditures to outfit scientific bases and laboratories. The maximum projections for motor vehicle production between now and 1995 call for increasing passenger car output to 2,170,000 units and bus output to 120,800 units annually. The minimum version of the plan calls for producing 1,212,000 passenger cars and 112,500 buses annually. Truck production is to be increased to 903,100 units annually, production of tractor trailers and semi-trailers is slated to increase to 353,200 units, and forklift truck output is to increase to 48,000 units annually. Corresponding development of the related sectors of machine tool building and cooperation with foreign firms are also needed. The time required to update and improve the domestic automotive industry will of course depend on the rest of the country's economy. Other changes slated for the USSR automotive industry include the gradual introduction of catalytic converters, increased production of compact cars (in cooperation with the firm Fiat, for example), introduction of a new generation of all-wheel-drive station wagons with payloads of 1.0 and 1.5 t, modernization of the GAZ-3307 gas-engine truck, and development of the GAZ-4509 (which will feature a new diesel engine with air cooling). Increasing fuel economy and extending vehicle life are other goals that have been set. The goal for vehicles produced at the Minsk Automotive Plant, for example, is to reduce fuel consumption by 15-20% and extend vehicle life to 600,000 km. The list of specialized and special motor vehicles intended for various purposes (including medical) is to be greatly expanded. A family of hydromechanical automatic transmissions with three, four, and five or more gears for buses using two or three type sizes of hydraulic transformers and electronic control systems is also planned. More attention will be paid to traffic safety and ergonomics, as well as to ecological problems. Plans call for increasing the number of catalytic converters and exhaust neutralization systems to 0.5 million annually by 1990 and for increasing the number of carbon filters for diesel engines to 100,000 units annually. Large-payload dump trucks are also slated for improvement: Their reliability is to be increased to 250,000-300,000 km, and their mean time to failure is to be increased to 10,000-15,000 km. Diesel trolley cars with a payload of 110 to 120 t are also slated for production; they should reduce fuel consumption by 30-70% and increase productivity by 12-20%. Measures have also been planned to make motor vehicles easier to service and

repair. These measures include simplifying the design of various auto parts and increasing their reliability, improving access to various vehicle subassemblies, and expanding the use of self-controlled nodes. Efforts to revise existing technical standards documentation and to develop scientifically well founded durability and wear standards, etc., are also in the works. Figures 2, tables 3.

**New-Generation Universal-Assembly Readjustable Machining Accessories [USPO]—An Important Means of Increasing Machining Accessories and Speeding up Manufacturing Preparations**

927F0040A Moscow VESTNIK

MASHINOSTROYENIYA in Russian No 9,  
Sep 91 pp 39-41

[Article by V.D. Biryukov and V.V. Popov, Interbranch Head Machining Accessories Design and Technology Institute, Kharkov]

UDC 62-29:658.512.2.011.56

[Abstract] Universal-assembly readjustable machining accessories are an effective way of increasing the machining accessories available for use in metal working. Domestic machine building has accrued a great deal of positive experience in using universal-assembly readjustable machining accessories in various metal working processes ranging from universal machine tools to flexible manufacturing systems and numeric control machine tools. All of the country's metal working enterprises are currently using universal-assembly accessories, and at some enterprises they constitute 60 to 80% of the total amount of equipment accessories used. The Interbranch Head Machining Accessories Design and Technology Institute [MGKTItekhnosnastki] had designed several new types of universal-assembly readjustable machining accessories, has arranged for their manufacture, and is supplying them to users. The institute is also providing a set of related services. These include (1) developing and supplying specialized accessory sets to allow for the specifics of an individual client's unique manufacturing conditions and (2) providing methodological, consultative, and technical assistance geared toward reducing the time required to introducing the new universal-assembly readjustable machining accessories and to increase their efficiency. Specifically, the institute is developing universal-assembly readjustable machining accessories for priority types of metal-cutting and press-forging equipment and is working to create new products at enterprises based on economic agreements with the client enterprises. The Ryazon SPO, for example, has recently been furnished with a metal working section consisting of eight flexible manufacturing modules with 500 x 500-mm tables and four such modules with 800 x 800-mm tables along with an entire series of universal machine tools. The Moscow Automated Line Plane imeni 50 Years of the USSR has been furnished with universal-assembly readjustable machining accessory sets outfitted with about 50 machining centers and NC machine tools. Special attention is being paid to the development of new high-precision accessories for robot

systems. One result of these efforts has been a new-generation universal-assembly readjustable machining accessory set with V-slots (the USPO-V). It actually surpasses a number of the world's best analogues (such as those produced by Ferra Tools, Andreas Maier, Kipp, and Bluco Technik) in a number of senses. It is, for example more stable and rigid by a factor of 1.7 to 2, more precise by an entire quality level, and requires less metal to manufacture (by a factor of 1.4). USPO-V systems are being used successfully at the Odessa SPO imeni V.I. Lenin and at the Izyum Optical Mechanics Plant. It has also been favorably received at a number of international exhibitions in Bulgaria, the Czech and Slovak Federated Republic, Italy, and the United States. It was awarded a gold medal in international machine building at the Leipzig Trade Fair in 1989 and has received many metals in the USSR. The MGKTItekhnosnastki is also working on universal-assembly readjustable machining accessories for other manufacturing operations as well. Its universal-assembly testing-and-measurement attachments [USKIP], for example, are intended for use in checking for straightness and planarity deviations and to check the relative location of the surfaces of large workpieces. The USKIP-K is intended for comprehensive inspection of base members and is capable of inspecting workpieces with distances from 60 to 1,200 mm between holes' axes and of checking the coaxiality of holes with diameters from 70 to 200 mm relative to a common axis. The MGKTItekhnosnastki has also developed universal-assembly readjustable stamping accessory sets, a set of universal readjustable dies for automated stamping operations, and a set of assembly-disassembly attachments for welding-and-assembly operations. Figure 1; references 4: 3 Russian, 1 Western.

#### **A Method of Analyzing the Precision Characteristics of Angle-Data Transmitters**

927F0045A Moscow IZMERITELNAYA  
TEKHNOLOGIYA in Russian No 4, Apr 91 pp 7-8

[Article by V.A. Smirnov, I.P. Glagolev, Yu.P. Dorokhin, and V.D. Fateyev]

UDC 531.74.087.92.088

[Abstract] Shaft angle encoders based on sine-cosine angle-data transmitters are widely used in automatic control systems. The precision of angle-data transmitters is one of the most important factors in determining the precision of shaft angle encoders. In view of this fact, the authors of this article have worked to develop a direct method of measuring the error of an angle-data transmitter at individual points by comparing the test angle-data transmitter to a "standard" transmitter. The error of an angle-data transmitter (i.e.,  $\Delta\alpha_k$ ) is measured at each k-th point and is determined as the difference between the codes of the angle-data transmitter being tested and the standard angle-data transmitter. After  $\Delta\alpha_k$  has been determined for a rather large number of discrete points (readings) and after the adjacent points have been approximated by curves, it is possible to derive the continuous function  $\Delta\alpha(\alpha)$ . The authors present a detailed mathematical analysis of each of the different harmonic components of the measurement

error of an angle-data transmitter along with a procedure for calculating them. They also present a method of reducing the number of readings required to correctly assess the precision of an angle-data transmitter. The theoretical limit to which the number of readouts may be reduced is  $2L + 1$ , where L is the number of most significant harmonics in the spectrum. Using the proposed method makes it possible to reduce the number of laborious angle measurements required significantly (tens of times over). Figure 1; references 3 (Russian).

#### **Correcting the Errors of Electromechanical Angle-Data Transmitters for Analog-to-Digital Conversion**

927F0045A Moscow IZMERITELNAYA  
TEKHNOLOGIYA in Russian No 4, Apr 91 pp 11-12

[Article by O.V. Zhuravskiy]

UDC 531.74.087.92.088.6

[Abstract] Electromechanical angle-data transmitters play an important role in automatic control, robot, etc., systems. At the present time, the most widely used methods of increasing the precision of angle-data transmitters may be classified as compensation methods. One point in favor of compensation methods is that the errors of angle-data transmitters are generally of a stable functional nature depending on the rotation angle. Several ways of reducing the errors of digital angle encoders currently exist, including compensation methods and the use of semiconductor correctors. Special electronic units, i.e., microprocessor error compensation systems, may be used to compensate for the systematic component of the error of electromechanical angle-data transmitters used in digital angle encoders. Random errors may also occur in the output signals of electromechanical angle-data transmitters and digital angle encoders. These are due primarily to such factors as fluctuations in power supply parameters, random deviations in the process of manufacturing the angle-data transmitters, operator errors, and changes in the system's inherent parameters over time. Operational errors also play a big role in increasing both the systematic and random components of the overall measuring circuit of a digital angle encoder. An increase in operational errors may, for example, disturb the coaxiality of an electromechanical angle-data transmitter's magnetic circuits when such circuits have been in operation for lengthy periods or when they are used in devices subject to outside disturbances. Semiconductor technology may be used to eliminate both the systematic and random errors caused by design and technological constraints and the aforementioned operational errors. Additional errors resulting from the design, manufacture, and operation processes may also be eliminated by using various correctors based on electronic technology. Their operation should be based on matching the voltages extracted from the windings of the electromechanical angle-data transmitter. This may be done by using a formula to compute the electromotive force of stator and rotor magnetic circuits that is provided by the author. References 7 (Russian).

**Correcting the Parameters of Multipole Induction Angle Encoders**927F0045C Moscow IZMERITELNAYA  
TEKHOLOGIYA in Russian No 4, Apr 91 pp 12-14

[Article by V.A. Batygin]

UDC 531.74.087.92.089.5.088.6

[Abstract] Thanks to their high precision and noise immunity, relatively low cost, and ability to operate under a wide variety of conditions, induction angle transducers continue to hold their top position among transducers. Efforts are currently under way in the USSR to reduce the error of induction angle encoders to tens of seconds of an angle or, in some cases, to single-digit seconds of an angle. In line with this effort, the author of this article presents methods of correcting three types of errors of induction angle encoders. Specifically, he suggests ways of compensating for intraperiod errors, short-period errors, and long-period errors. The intraperiod error of an induction angle encoder includes harmonics whose period is a multiple of the period  $p$  of the change in the envelope of the induction angle encoder's output voltage. Such errors may be compensated for in the induction angle encoder itself. It is, for example, possible to reduce nonsinusoidality by increasing the number of slots in the repeating part of the stator. Nonperpendicularity of windings, on the other hand, may be corrected by shifting the axis of one of the windings without changing its harmonic profile. This is accomplished by connecting a control winding in series with one of the windings. The period of the change in a short-period error is not a multiple of the period of the change in the envelope of an induction angle encoder's output voltage. Short-period errors result from technological deviations when the tooth zone is manufactured. From the standpoint of such deviations, an induction angle encoder is like a band-pass filter. Errors of the short-period type may be corrected by introducing compensations for those harmonics of the error of the angular arrangement of slots that are causing the errors. Other methods of correcting short-period errors include adding an additional rotor and determining the number of teeth it will have based on the period of change in the error induced in the output windings in the event of asymmetry of the location of the slots and asymmetry of the air gap that results from the turn angle of the electromotive force. Long-period errors refer to the first harmonic of error caused by the combined effect of air gap asymmetry and the angular location of the slots. The simplest way of reducing long-period error is to increase the air gap. These and other techniques for correcting and compensating for errors in the induction angle encoder are discussed in detail. Figures 2, tables 2; references 8 (Russian).

**Two-Channel Precision Angle Encoder**927F0045D Moscow IZMERITELNAYA  
TEKHOLOGIYA in Russian No 4, Apr 91 pp 8-9

[Article by I.P. Glagolev, Yu.P. Dorokhin, V.F. Mamich, V.A. Smirnov, and V.D. Fateyev]

UDC 531.74.087.92.088

[Abstract] The authors discuss the problems facing designers of high-precision shaft angle encoders (i.e., encoders with an error not exceeding  $\pm 1''$ ). They pay special attention to the problem of developing high-precision monitoring of an encoder's metrologic characteristics during the process of its operation so as to determine and make allowances for the dynamics of errors arising as a result of external operational factors. The authors also focus their attention on the development of corrections to compensate for the main components of an angle encoder's error. The said correction methods are designed for use with shaft angle encoders based on sine-cosine angle-data transmitters with an electrical reduction of  $p$  and  $n$  sensors that are distributed evenly throughout the air gap and that are governed by a sine sensitivity distribution law. The error spectrum of such shaft angle encoders contains a limited number of harmonics of significant amplitude: harmonics of orders of magnitude that are multiples of  $p$  (3 to 5 harmonics and generally not more than  $5p$  harmonics); harmonics of orders that are multiples of  $n$  (2 to 3 and generally not exceeding  $7n$ ); and harmonics with orders of magnitude of 1,  $p \pm 1$ , and  $2p \pm 1$ . The harmonic profile of the error spectrum of shaft angle encoders of the said type is maintained from individual encoder to encoder and under all operating conditions; only the amplitudes and phases of the harmonics' components change. In view of this fact, the authors have developed a spatial frequency discrimination method to compensate for the operation errors of shaft angle encoders. A two-channel angle-data transmitter has been designed for use in implementing the new error correction method. The new two-channel angle-data transmitter is mounted on the axis being measured and is designed so that the shaft angle encoders designed on the basis of these channels have error spectra that differ from a harmonic profile standpoint. Procedures and mathematical expressions for use in implementing the new spatial frequency discrimination error correction method are provided. One problem arising in the use of the new method is that it is not suitable for error harmonics of coinciding orders of magnitude. Procedures are therefore suggested for minimizing the error component resulting from the fact that the fundamental harmonic is present in the error spectra of all shaft angle encoders regardless of their structure. The new spatial frequency discrimination method simplifies the process of certifying shaft angle encoders and is itself simple from a hardware standpoint. In the example presented herein, using the spatial frequency discrimination error correction method resulted in a reduction in the error of the primary channel from  $\pm 2.6$  to  $\pm 0.67''$ . Figures 2; references 2 (Russian).



**Multicomponent Analog-to-Digital Motion Converters With Sine-Cosine Transducers**

927F0045E Moscow IZMERITELNAYA  
TEKHNOLOGIYA in Russian No 4, Apr 91 pp 14-16

[Article by Yu.S. Smirnov]

UDC 531.74.087.92:681.3.06+531.76.087.92:681.3.06

[Abstract] Using electromechanotronic converters to convert a microprocessor's output signals into motion requires information base organization and support for the electromechanical conversion process. One graphic example is the case of manipulation robots, the operating efficiency of which is governed by the speed and precision of the electromechanotronic transducers used in the manipulator's links. The best electromechanotronic converters are those equipped with positional feedback. Improving the performance indicators of electromechanotronic converters thus hinges on improving their positional feedback loops. One way of simplifying and increasing the efficiency of an electromechanotronic converter's feedback loop is to use the principle of a unified information base organization and support system that would make it possible to obtain both position and velocity signals from one transducer. As such a converter, it is best to use a sine-cosine transducer combined with an electronic unit conditioning digital equivalents of angle and velocity from its output signals. This digitization may be accomplished by means of an analog-to-digital tachometry technique that provides single-channel differentiation of the lesser of the sine-cosine transducer's two output signals within the bounds of an octant followed by division of its modulus by the modulus of the greater signal. The operations of division and formation of the digital equivalent of the velocity may be combined in a voltage ratio analog-to-digital converter, which makes such a tachometer highly compatible with a secondary position digitizer in the case of octant subdivision of the range of the angle being converted. The author describes and diagrams a two-component shaft position digitizer implementing the analog-to-digital tachometry technique. It consists of a common section and two component conversion channels. The common section contains a sine-cosine transducer, octant detector, and analog switch. It is in the common section that the intracircuit running values of the reference and signal direct voltages at the outputs of the analog switch and a three-bit code of the octant at the output of the octant detector are formed. The component conversion channels form digital equivalents of the angle and velocity in parallel by using the principle of direct analog-to-digital conversion in each of the channels. The operation of the new two-component shaft position digitizer is explained along with ways of overcoming some of the problems that arose during its development. The new shaft position digitizer makes it possible to transfer the formation of the higher levels of information organization and support from the electromechanical portion of an electromechanotronic converter to its electronic part, thereby greatly simplifying and improving the performance indicator of such electromechanotronic converters and in turn increasing the conversion precision of shaft digitizers. Figures 2; references 10: 7 Russian, 3 Western.

**Increasing the Precision of Devices Measuring Movement Parameters**

927F0045F Moscow IZMERITELNAYA  
TEKHNOLOGIYA in Russian No 4, Apr 91 pp 16-18

[Article by A.V. Bogdashev, I.E. Kan, M.S. Kaplun, and V.V. Klimovitskaya]

UDC 621.323.382.3.004.14:681.84.083.8

[Abstract] The authors discuss methods of increasing the precision of devices measuring the parameters of movements. Specifically, they focus their attention on the use of multichannel measuring systems as a way of increasing dynamic measurement precision without reducing static precision. They discuss two different ways of increasing dynamic measurement precision by way of the example of two different devices to measure movement parameters. Each of the two devices reflects a different method of implementing the readout portion of the device with an imaginary increase in the equivalent number of transducer output windings. The first device is based on the principle of frequency multiplication, whereas the second is based on the principle of frequency division. Calculations performed by the authors confirmed that multichannel circuits with frequency multiplication or division may indeed increase both the static and dynamic precision of instruments measuring movement parameters when the said instruments are based on rotary transformer- or synchrotype electromagnetic transducers. Using the principle of frequency multiplication was found to yield a greater range of measurable movement parameters than does using the frequency division principle. Frequency multiplication is more complex, however, and has a specific error caused by angle modulation of the amplitude of the output signal of the sine-cosine rotary transformer. Increasing the electromagnetic reduction coefficient was found to make it possible to proportionally increase the static precision of instruments measuring movement parameters. Finally, the authors also caution that when multichannel instruments measuring movement parameters are used in closed-loop automatic control systems, consideration must be given to the fact that the given devices measure movement parameters that are actually averaged within a time interval. Figures 2; reference 1 (Russian).

**A Tracker Position Digitizer With Expanded Functional Capabilities**

927F0045G Moscow IZMERITELNAYA  
TEKHNOLOGIYA in Russian No 4, Apr 91 pp 18-19

[Article by M.S. Kaplun, A.V. Bogdashev, I.E. Kan, V.V. Klimovitskaya, and P.N. Kovalev]

UDC 621.323.382.3.004.14:681.84.083.8

[Abstract] The increasing complexity of the motions reproduced by electric drives and their kinematic diagrams has spawned increased interest in measurement instruments that make it possible to form digital equivalents of movement parameters by conversion of the output signal of a single transducer. In view of this fact, the authors of the research reported herein examined a multifunctional



tracking position digitizer based on a sine-cosine rotary transformer operating in an amplitude mode. The new position digitizer includes the following: two multiplication units, a digital sine-cosine rotary transformer, two comparators, a phase detector, a digital integrator, an n-channel digital integrator, an n-channel storage register, an electronic switch, and a query pulse former. The main factor limiting the new position digitizer's precision indicators is the presence of a hardware delay in the signal's passage in the loop of the tracking device. The position digitizer can be made to function to the full extent of its capabilities by equipping it with a node to measure rotation frequency. This node may be implemented in the form of a multichannel cyclic motion parameter converter. The contradiction between the conditions of simultaneously achieving high static and dynamic precision may be minimized by selecting the number of frequency rotation meters and frequency rotation meter channels. Figure 1; references 2 (Russian).

#### **A Digital Converter With Quadrature Filtration of Angle-Data Transmitter Signals**

927F0045H Moscow IZMERITELNAYA  
TEKHNOLOGIYA in Russian No 4, Apr 91 pp 19-21

[Article by M.Ye. Kurlov and B.A. Sarychev]

UDC 531.74.087.92

[Abstract] Shaft angle encoders are becoming increasingly important in modern automated systems. Amplitude converters based on sine-cosine rotary transformer-type analog electromechanical angle-data transmitters are among the most popular type of shaft angle encoders. In the past few years, the use of microprocessor sets to encode the signals of such encoders has become far more widespread. One such technique entails using digital filtration of the output signals of the sine-cosine rotary transformer after they have first been digitized by linear analog-to-digital converters. The authors of this article developed a new shaft angle encoder based on the aforesaid principles. A prototype of the proposed encoder was constructed on the basis of a series K588 microprocessor set. A type 5BVT dipole sine-cosine rotary transformer was used as the angle-data transmitter. Experiments performed on the

prototype shaft angle encoder both with and without a quadrature digital filter revealed that adding such a filter significantly reduces the error of the new shaft encoder's coding angle and increases its precision by a factor of 2 to 3. In other words, its mean square deviation was reduced from 3' (without the use of quadrature filtration) to 1' when quadrature filtration was used. Digital implementation of the filter not only increased conversion precision and noise immunity but also simplified the new encoder overall. The studies performed on the prototype shaft angle encoder confirmed that the high-frequency component of the coding error can be filtered out entirely while the low-frequency component may be written (in the form of a correction code) into the angle digitizer's memory, thus increasing conversion precision to the level of the angle digitizer's resolution. Figures 2; references 3 (Russian).

#### **A Photoelectric Phase Position Encoder**

927F0045I Moscow IZMERITELNAYA  
TEKHNOLOGIYA in Russian No 4, Apr 91 pp 21-22

[Article by A.V. Kosinskiy, A.Ye. Popov, and A.A. Khomomonov]

UDC 621.314.252:681.142.37

[Abstract] One promising direction in the design of photoelectric phase position encoders is that of using multiunit photodetectors to detect optical radiation and to condition a signal with an envelope of the required shape. The operating principle of a photoelectric phase position encoder based on a multiunit photodetector is as follows. A luminous flux passes from the radiation source and through the optical system. The latter forms a narrow slit of light on the working surface of the multiunit photodetector. This slit intersects all of the multiunit photodetector's discrete photosensitive paths in such a manner that the active resistance between the current-conducting buses of the latter change in accordance with a developer-specified law. The authors of this article present a series of calculations substantiating the theoretical possibility of designing and constructing a photoelectric phase position encoder based on a multiunit photodetector that would combine the advantages of low weight and small size with the benefits of the phase method of encoding movements. Figures 2; references 4 (Russian).